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Early Days at Mount Wilson

By WALTER S. ADAMS

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One of our earliest visitors on the mountain was Professor Turner of Oxford who, with Mrs. Turner, was making a trip through the United States. The Monastery being under construction, the only living quarters we could give them was the small wooden engine house which had just been completed. Here they lived in apparent comfort for a week, having the gas engine as a close companion and dining with us at the casino. Although Turner was hardly built for mountain climbing, we all explored the top of the mountain and made a few expeditions into nearby-by canyons. On one of these into the Santa Anita Canyon we encountered an owl and tried hard to secure him for Turner as a trophy, but without success. This trip figured later in his "Oxford Note Book," as we might have anticipated.

During the first year of our occupancy of the Monastery, Professor Barnard came out from the Yerkes Observatory on a special expedition, bringing with him the Bruce telescope to photograph a portion of the southern Milky Way. Of course all of us knew him well and it was a delight to have him with us on the mountain. He at once fell in love with the mountain and everything connected with it: he was fascinated by the views, studied the birds, measured the growth of yucca stalks, and treasured the sight of a deer. I remember his excitement one winter morning when he came in to breakfast and announced that he had just seen a wildcat walking through the snow outside his bedroom window. His interest in the old burro Pinto, and the scientific use he made of a few of Pinto's stray hairs, I have already mentioned. Barnard's devotion to the mountain may be judged by the fact that during four months of his stay he made but one trip to the valley. This was to Sierra Madre to see a notary and to have his hair cut, after which he turned around and started back up the trail. His health was excellent at this time, and to those who knew him in later years it will be a surprise to learn that he once clambered down the steep walls of the ridge below the Monastery, crossed the deep canyon, and climbed the side of Mount Harvard to the toll road, perhaps as difficult a trip as any around the mountain top.

Barnard's hours of work would have horrified any medical man. Sleep he considered a sheer waste of time, and for long intervals would forget it altogether. After observing until midnight, he would drink

a large quantity of coffee, work the remainder of the night, develop his photographs, and then join the solar observers at breakfast. The morning he would spend in washing his plates, which was done by successive changes of water, since running water was not yet available. On rare occasions he would take a nap in the afternoon, but usually he would spend the time around his telescope. He liked to sing, although far from gifted in the art, but reserved his singing for times when he was feeling particularly cheerful. Accordingly, when we at the Monastery heard various doleful sounds coming down the slope from the direction of the Bruce telescope, we knew that everything was going well and that the seeing was good.

The Bruce telescope was housed in a small wooden building with a floor about three feet above the ground. A trap door in this floor gave access to the weights of the driving clock which were suspended by a cable. When the telescope was pointed high in the sky, Barnard often found it convenient when guiding to open the trap door and sit on the floor with his legs dangling through the opening. One summer morning at breakfast he casually mentioned to us that he heard some odd rustling sounds beneath him during several preceding nights. On examination we found and succeeded in killing a fair-sized rattlesnake which had been making his home below the floor. Whether the snake had ever attempted to investigate the intruding legs we never knew, but Barnard took the episode quite calmly and on the following night the trap door was open as usual.

One individual who interested Barnard greatly was a professional rain maker, Hatfield by name, who was operating in southern California during the winter of Barnard's stay. It seems that this part of the state had suffered a succession of three dry winters, and, since dependence upon local rainfall was much greater then than now, the somewhat gullible Merchants Association of Los Angeles decided to enlist the services of a rain maker. Accordingly, they entered into a contract with Hatfield by the terms of which he was to receive $1,000 if the rainfall in Los Angeles during the following winter amounted to the seasonal average of 15 inches, but was to receive nothing if it fell below that amount. This agreement, needless to say, was highly satisfactory to Hatfield since his equipment, consisting of a temporary wooden tower about 20 feet high and a few small pans in which he placed chemicals, would have been overvalued at fifty dollars. The chemicals, the nature of which he kept secret but which may have been calcium chloride, were supposed in his words "to attract the moisture-laden atmosphere," and thus produce rain. When Barnard learned of these negotiations he was greatly amused, and whenever a cloud came up over the horizon he would say, "Mr. Hatfield must be at work." The winter proved to be a stormy one with a rainfall of about 20 inches, so that Hatfield collected his $1,000 and went on his way rejoicing.

For years afterward Barnard, once more back at the Yerkes Observa-

tory, would write to ask for any news of Hatfield, and was much pleased to learn of the suit brought by the City of San Diego against the rain maker, then operating in that city, for producing a flood which broke several reservoirs and washed out many of the streets. In later years Hatfield overplayed his hand and undertook to break a drought in western Canada. Here he got into difficulties with the authorities and was invited to leave the country on short notice.

In 1905, Henry Gale, then instructor in physics at the University of Chicago, was invited by Hale to come to Mount Wilson and spend a year at the small spectroscopic laboratory which had just been completed on the mountain. This was the beginning of a friendship which extended over many years. The first photographs of sunspot spectra had just been obtained and we worked together in the laboratory in the attempt to duplicate the differences among groups of lines observed in spots. The sources used included the direct-current arc at various current strengths, the rotating arc recently invented by Henry Crew, and finally the core and the outer flame of the arc. The experiments proved successful and led to the classification of lines into groups according to temperature, which has had many applications in stellar spectroscopy and in the analysis of the atomic spectra of the chemical elements.

Gale's powerful figure surmounted by a huge curved pipe was one of the familiar and most pleasant sights of that second winter on the mountain, the first at the Monastery. At this time the Mount Wilson Hotel was visited by us frequently, usually for the purchase of tobacco. The short, steep climb toward the laboratory on the return journey worried Gale, and at his suggestion the two of us undertook the construction of a trail of nearly uniform grade, beginning near the battery room and extending across the slope below the laboratory and around a sharp point to the dividing line with the hotel grounds. Gale worked manfully on this project, which when completed was named the "Lucky Strike Trail" after the brand of tobacco usually found at the journey's end. The trail was used for several years but in the course of time was almost completely obliterated by winter storms.

The group at the Monastery had many good times together during this period. Abbot and his assistant, Ingersoll, of the physics department of the University of Wisconsin, were making the first of the many Smithsonian expeditions to Mount Wilson, and their presence added greatly to the pleasure of life on the mountain. Hale had introduced Abbot to the Oriental stories in Beckford's book on the monasteries of the Levant, and our evenings usually started off with a dramatic rendering by Abbot of the tale of the Jew of Constantinople and Solomon's Seal which he knew by heart. Occasionally the Smithsonian challenged all comers to a game of duplicate whist, but more often the group would gather around the fireplace for discussions of plans of work or of the state of the world in general. Hale's amazing breadth of interests, his great personal charm, and his stories of important figures in science and

national and international affairs make these evenings stand out in memory. Other incidents were not lacking, and I remember one evening when the gathering was temporarily broken up by a large scorpion which suddenly made his appearance on the hearth of the fireplace. Gale, who was drying his feet and had his shoes off, hastily climbed up the book shelves and more or less circumnavigated the room in this fashion on his way to the door. At this time the 60-inch telescope was not yet in commission and nearly all the observing was limited to the sun. After night work began, these evening gatherings necessarily became much fewer, and I remember Abbot's pathetic lament that "the 60-inch telescope has spoiled the mountain."

Of the many pleasant recollections of Abbot's visits to the mountain, one deserves mention as an illustration both of his sense of humor and of his excellent upbringing as a youth. Transportation to Mount Wilson had passed through the successive stages of walking, riding a burro or mule, or of traveling in a mule-drawn wagon. Finally, in 1912 the Observatory purchased a Mack truck, the sketeton of which still reposes in the 100-inch telescope building. Its tires were solid, its springs rudimentary, and its riding qualities were similar to those of a tractor in a plowed field. Not long after the truck went into commission, Abbot arrived for his annual visit to Mount Wilson. He had had wide experience with all the other methods of transportation, and we placed him on board the truck wondering what his reaction would be. About three hours later my telephone rang and after a moment a voice said: "This is Abbot. As I came up the mountain this morning I was reminded of a verse from an old hymn of my childhood, 'Shall I be carried to the skies on flowery beds to ease while others fight to win the prize, or sail o'er stormy seas.' "

We had many other scientific visitors during these early years, among them Evershed of England, Julius of anomalous dispersion fame, and E. F. Nichols, who made some measurements of very long-wave solar radiation with a radiometer. The visit which I remember best, however, was that of Simon Newcomb, chiefly because of the variety of troubles I experienced in connection with it. The first intimation of his coming was in the form of a telegram sent from a Santa Fé train announcing that he was arriving the following morning at the Santa Anita station to go up Mount Wilson. Hale was in the East and it devolved upon me to make the necessary arrangements and go up the trail with him. By this time the streetcar line had been extended to Sierra Madre, so I telegraphed Newcomb to continue on the train to Los Angeles and come out on the carline. So the next morning I boarded the appropriate Sierra Madre car at the Colorado Street intersection and found Newcomb on board, recognizing him without difficulty although I had never met him previously.

At the foot of the trail we found the two mules, engaged in advance, waiting for us. Newcomb looked at his mule somewhat suspiciously

and I had a premonition that his experience with this sagacious animal might have been limited. We succeeded in getting Newcomb into his saddle, however, and started up the trail, my mule leading the way. After we had gone about half a mile we met a pack mule coming down the trail by himself and evidently on his way to his corral and the food he was anticipating. As was often the case after going up the mountain in a packtrain, he had been unloaded and then turned loose to find his own way back home. The mule brushed past and my animal proceeded on his way. A minute or two later, however, I looked back to see how Newcomb was progressing and found that he had disappeared completely. He had been riding with a loose rein and his mule had seized the opportunity to pivot around and follow his comrade back to the delights of the stable. So I returned to the foot of the trail and there found Newcomb in a state of great excitement vowing that the trip was too dangerous; and it required the united persuasion of everyone at the corral to get him back into the saddle again. This time we succeeded in reaching the top of the mountain, but the journey was a hectic one. The day was warm and Newcomb proceeded to open an umbrella to protect his head from the sun. This did not improve the disposition of the mule who shied every time the umbrella touched a bit of brush along the way. So our progress was in a series of jerks as the mule shied, and these worried Newcomb as he looked down the steep canyon walls. In addition, he seemed to anticipate meeting in such wild surroundings every sort of creature from a centipede to a brown bear. All these factors tended to emphasize certain characteristics of Newcomb wherein he differed from the Christian saints, and by the time we reached the Monastery he was in a state of mind to make a dinner upon a menu of wire nails.

At the Observatory the only things which interested Newcomb to any extent were the Riefler clocks in the laboratory and the Snow telescope building. These he examined closely. The coelostat and concave mirror combination he dismissed briefly as not forming a real telescope, and the spectrographs and spectroheliograph were not merely a closed book to his mind but one which ought to remain closed. In fact, Newcomb's attitude toward the spectrum resembled closely that of Burnham whose famous remark to Hough, "Gale showed me the soda lines once at the Ryerson Laboratory but I didn't think much of them," has become a classic in astronomical literature.

The following day Newcomb and I returned to the valley, the plan being to use the same mules which had brought us up the mountain and had been kept at the hotel for this purpose. As soon as Newcomb sighted the animals, however, he announced that he would try walking for a short distance. So he started out and I followed, riding one mule and driving the other. Expecting to overtake him at any moment I did not actually do so until we reached the halfway house on the Sierra Madre trail. There I found Newcomb sitting at a table drinking ginger ale

out of a bottle and enormously pleased with himself over his ability to cover four miles of the mountain trail on foot. I strongly suspect that his satisfaction was due quite as much to the fact that he had avoided riding his mule for this distance. He was ready by this time, however, to board his animal and we rode the rest of the way without difficulty. When I left him on the streetcar on his way to Los Angeles, he was a vastly more genial Newcomb than I had known previously, doubtless because he was treasuring the thought that he had placed behind him the wild and dangerous expedition to Mount Wilson.

The general public found its way comparatively little to Mount Wilson at this time, difficulties of transportation operating to limit our visitors to those who had a more or less intelligent interest in astronomy or a love of the mountains. Occasionally some exceptional event, especially if featured in the press, would bring a throng, and we were overrun at the time of the return of Halley's Comet in 1910, when more than a few seemed to anticipate the end of the world, and apparently wished to be in close touch with those who were presumed to have inside knowledge of the various stages of the catastrophe. Much of the time, however, our visitors were so few that when we were observing we could leave the door of the buildings open for the stray wayfarer to wander in and gain such information as he could. On one such occasion, Ellerman at the 60-foot tower telescope fell into conversation with an individual who proved to be an enthusiastic photographer. They discussed cameras and lenses and their respective merits, but Ellerman decided to close the subject when the photographer remarked casually: "I had a wonderfully fine Tessar lens at one time but overstrained it in trying to photograph too wide a field and it never did so well afterward." A somewhat comparable incident happened when I was using the 30-foot spectrograph at the 60-foot tower. An elderly man appeared at the door and expressed an interest in what was going on. He had apparently used pigments considerably and was interested in colors. So at a good stopping place in the observations I showed him the spectrum near the magnesium lines in the green. He took a long look, then came away and said, "I don't call that a very good green." I could only tell him that this was the best that Nature could do for him.

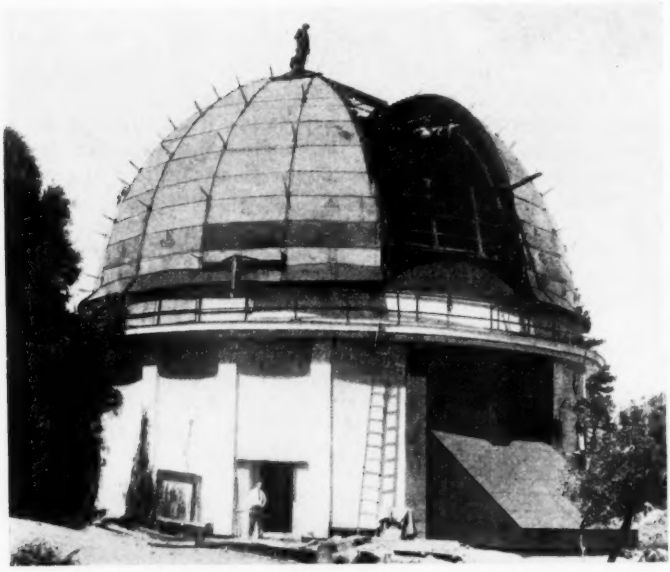
The construction, transportation, and erection of the 60-inch telescope with its building and dome furnished a major problem to the Observatory for a period of nearly two years. The dome and the heavy parts of the mounting were built by the Union Iron Works of San Francisco, and the driving clock and the control mechanisms by an instrument shop in Pasadena. Transportation was a very serious difficulty. The new trail had to be widened into a road, and the work had to be done almost wholly by hand, with mule-drawn scrapers and plows to move the earth. At many places bags filled with sand were used to build retaining walls to support the road. Actually the construction of the toll road, as it was known in later years, took place in two stages: the first widening was

to provide for the transportation of the 60-inch telescope; and the second and final widening about ten years later for that of the 100-inch telescope. At the time of the second widening some use could be made of mechanical equipment, such as power shovels and drills, although hand labor was still necessary for much of the work.

For the transportation of the heavy parts of the telescope the Observatory purchased a remarkable type of truck, only a few units of which were ever manufactured. Its power plant consisted of a gasoline engine which operated a generator which in turn furnished electric current to four motors installed in the wheels of the truck. The independent operation of the wheels was most useful on the sharp turns of the narrow mountain road, but the power proved inadequate for the steep grades. Finally the mechanical power was supplemented by the addition of mulepower, and a pair of these animals formed a regular part of the equipment when the heaviest loads were being taken up the mountain. Since the rate of progress of this caravan was very slow, a trip to the summit could not always be made in one day, and camping equipment was taken along as well. The picturesque character of this complex outfit had to be seen to be fully appreciated.

It was at this time that the Observatory began to realize the remarkable abilities of Jerry Dowd, who later was engineer on the mountain for many years and designed and built nearly all the electrical equipment which has already lasted throughout a generation. Dowd drove the electric truck on all the most difficult trips, being the only person with a thorough knowledge of its various peculiarities. The danger involved in this type of transportation on a very narrow road was considerable, and the demands on courage as well as physical endurance were great. To Jerry Dowd and George Jones belongs the credit for the solution of nearly all the problems which were encountered in the physical development of the Observatory at this period and in later years.

The completion of the 60-inch telescope brought a considerable increase in the staff of the Observatory. Seares came to organize the computational work and to begin his admirable series of photometric investigations. Babcock also came, of whom Hale once said: "What the Observatory needs is a half a dozen Babcocks." King began his fundamental studies with the electric furnace in the Pasadena laboratory, and the activities of the Observatory expanded in many directions. St. John, whose genial personality and ability in research were such an asset to the Observatory for nearly thirty years, was added to the staff of solar observers in 1909; and John Anderson with his extensive experience at Johns Hopkins University and his profound knowledge of applied optics came shortly afterward to undertake plans for the ruling machine. Observations with the 60-inch telescope were carried on at first mainly by Ritchey, Babcock, Adams, and Pease, who had assisted previously in the design and construction of the telescope in the Pasadena shop. Van



Dome of 60-inch Reflector (1908)

Professor and Mrs. H. H. Turner and Dr. Hale on Mount Wilson in 1904

Rijn and van Maanen came in the summer of 1911 as volunteer assistants, and van Maanen remained as a member of the staff to begin his association of thirty-five years with the Observatory. Arnold Kohlschütter of the Hamburg Observatory also came as a temporary visitor but continued as an assistant on the staff until the outbreak of the first World War in 1914. Störmer, Hertzsprung, and others carried on investigations for a few months on the mountain, and Professor Kapteyn made the first of the successive visits which were of such great value in planning the program of the work of the 60-inch telescope.

This was a period of intense activity in many fields. Hale had just discovered the Zeeman effect in sunspots, and measurements of field strengths in spots and of line-separations in laboratory sources were being carried on vigorously; studies of the rotation of the sun, of convection current in spots, and of general circulations in the sun's atmosphere were in progress; the effects of absolute magnitude upon stellar spectra were being investigated, and the discovery of the spectroscopic method of determining the distances of stars was close at hand; and the magnificent direct photographs with the 60-inch telescope were beginning to open the rich field of nebular study. Moreover, most of the members of the staff were in the prime of life and, for example, thought little of walking up the mountain in an afternoon, adjusting or changing their instruments, and working throughout the following night. The only cloud on the horizon was Hale's illness, which necessitated his absence from the Observatory for more than a year. He never recovered his health completely in later years and could make relatively few trips to the mountain, which was never the same without him.

The year 1910 was notable for the visit of Mr. Carnegie, the meeting of the International Solar Union on Mount Wilson, and the completion of the 150-foot tower telescope. Mr. Carnegie's visit took place in March and the party included Mrs. Carnegie and their daughter, Margaret, together with Mr. and Mrs. Hale and Margaret Hale. The two young girls were of nearly the same age and their activity added greatly to everybody's enjoyment. Transportation was by horse and carriage up the toll road, still something of an adventure in those days. The weather was cold and I remember that the night observers contributed several fur coats to the comfort of some members of the party. It snowed during the night which was spent on the mountain, but fortunately not enough to block the road on the following day. This visit was the occasion for the construction of the famous "Carnegie box" which ornamented the 60-inch telescope dome for so many years, and was invaluable in the changing of heavy instruments at the Cassegrain focus. Hale had feared that Carnegie would be unable to climb the steps to the floor of the dome and this box was built for the purpose of raising him to the floor by means of a chain hoist. It was made of two-inch planks reinforced at the corners with metal rods to inspire special confidence, and was designed by Ritchey who believed in factors of safety

A. Davidson Hale McBride H. F. Osburn Scherer
John Muir Hooker Carnegie

CARNEGIE IN PASADENA, 1910

of one hundred or more. Fortunately, Mr. Carnegie was not informed of the plan in advance. The box was placed on the concrete floor near the foot of the stairs, but when Carnegie arrived he took merely a casual glance at it and went up the steps like a boy out of school.

Mr. Carnegie was in excellent form during this visit. He was photographed repeatedly with Hale, always taking the higher position on a slope since he was somewhat sensitive about his height. To a reporter who asked him a question he remarked with a twinkle in his eye, "The protective tariff has outlived its usefulness." He was much interested in the Observatory equipment and asked many questions about the work in progress. That he did not altogether grasp the scientific point of view was evident when on his return to New York he announced that "60,000 new stars had been discovered" with the telescope at Mount

Wilson, evidently a reference to Ritchey's photographs of the Hercules cluster. This elicited the rather cynical remark from Moulton of the University of Chicago that one might equally well speak of having "discovered 60,000 new gallons of water" in Lake Michigan. Nevertheless, a great deal could be forgiven, for within a few weeks Mr. Carnegie showed his appreciation in a highly practical and generous way. In a letter to Dr. Woodward, president of the Institution, Carnegie stated that he was adding $10,000,000 to its endowment and expressed the desire that the work at Mount Wilson be pushed forward as rapidly as possible. This had particular reference to the completion of the 100-inch telescope, a project initiated a few years before by Mr. Hooker of Los Angeles with a gift of $45,000 for the purchase of the mirror. The glass disk was available at the time of Mr. Carnegie's visit.

Much might be written about the meeting of the International Solar Union on Mount Wilson in August of 1910. The Union had been established mainly through Hale's efforts and was an active organization by no means limited to considerations of solar problems, but embracing most of the field of astrophysics in general. The Carnegie Institution was able to contribute toward the cost of travel of the delegates, and there was a large attendance from many European countries as well as from the United States. The foreign delegates, who traveled mainly in one group, were met in Chicago by Wendell Hoge, later for many years night assistant on Mount Wilson, but at that time in the employ of the Santa Fé Railroad, under whose escort they made the journey to Pasadena. As he said later, he enjoyed the experience greatly in retrospect, but aged considerably during the actual days of travel. To most of the delegates the desert was new and interesting, and as scientists they were traditionally absent-minded and regardless of timetables. As a result, when the train stopped in the middle of the desert for the engine to take on water, they would instantly get off and scatter all over the countryside to examine the cactus plants or the desert formations. It devolved upon Hoge to round them up, shepherd them into the train, and placate the enraged conductor. In the end, however, they reached Pasadena with only one or two persons missing, and these followed on a later train.

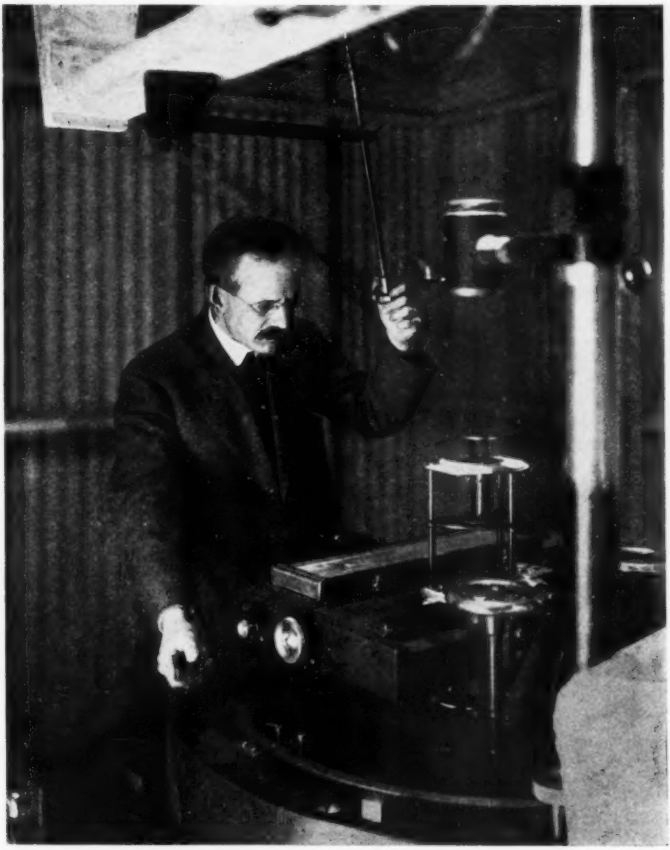
Arrangements had been made to take the delegates up Mount Wilson partly in horse-drawn carriages over the toll road, and partly on mules and burros over the Sierra Madre trail. In the carriage in which I happened to be were Sir Joseph Larmor, Frank Dyson, later Sir Frank and Astronomer Royal of England, and Professor Barnard. Halfway up the road a whiffletree struck a projecting rock and was broken. I volunteered to hurry ahead and stop the next carriage, which was not very far away, while the others followed at their leisure. A short distance up the road on an inside curve I stopped to see how the others were getting along, and have always regretted the absence of a camera to record the expressions of these famous scientists. All three had shed

their coats and had settled down to serious business, plodding along, Barnard with a look of placid determination, and Sir Joseph and Dyson with the grim resolution and doggedness characteristic of their race.

On the Sierra Madre trail all came through successfully, although there was some nervousness and a tendency to lean toward the inside wall when the mules swung widely at the turns and the rider nearly overhung the canyon. One enterprising person, Dr. Rydberg, the well-known Swedish spectroscopist, hit on the plan of singing gently to his mule to soothe his feelings and make him more conservative in his actions. The actual effect upon the mule of these songs in a foreign tongue was never determined scientifically, but Rydberg believed firmly in their efficacy and the singing was maintained throughout the journey.

The meetings on the mountain, held in the old museum building on the site of the present auditorium, were most interesting and much was accomplished in the way of adopting standards of reference to be used in future investigations, and in formulating plans for co-operative work. Some of these had to be laid aside in the great upheaval produced by the first World War, but were taken up again when the International Astronomical Union was organized. For example, it was at this 1910 meeting on Mount Wilson that the Harvard system of classification of stellar spectra was officially adopted, greatly to the satisfaction of Pickering, who was present, and a system of secondary standards of wave lengths was selected in order to bring some order into the chaotic situation which had existed previously. This was one of the last international scientific gatherings at which Germany was represented officially, and Schwarzschild of Potsdam and Kayser and Küstner of Bonn were among those present. France had Fabry and Deslandres and a small group of younger scientists. England had a large representation, including Schuster, the much-beloved Newall, and Father Cortie, in addition to Larmor and Dyson. From other countries of Europe came the genial Belopolsky, Backlund, Riccò of Italy, the tuneful Rydberg, and of course, Kapteyn, who was on one of his visits to Mount Wilson at this time. A total of about eighty representatives attended the meetings.

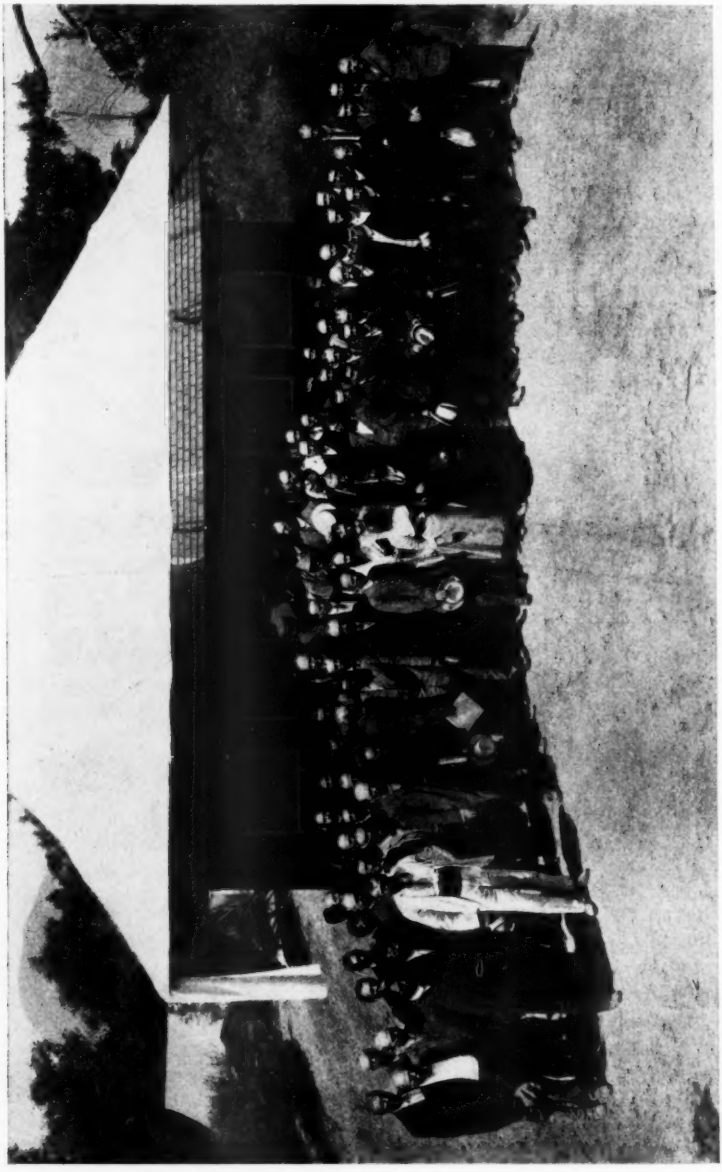
The reactions of a group of individuals from all over the world with different languages and customs, when brought together in so isolated and primitive a spot as the top of Mount Wilson in these early years, were interesting and often amusing. Almost without exception they enjoyed themselves hugely, and a familiar sight was that of groups of three or four wandering around the mountain examining the novel trees and shrubs, or immersed in a technical astronomical discussion. The single exception which I remember was one of the very few ladies present, the wife of a Rumanian astronomer with great estates in Bessarabia, who glanced at the rather spartan facilities of the cottages of the Mount Wilson Hotel, exclaimed, "This is no place for a lady," and departed hastily to the comforts of the valley. I remember meeting Schwarzschild, under whom I had been a student at Munich, wandering



GEORGE ELLERY HALE

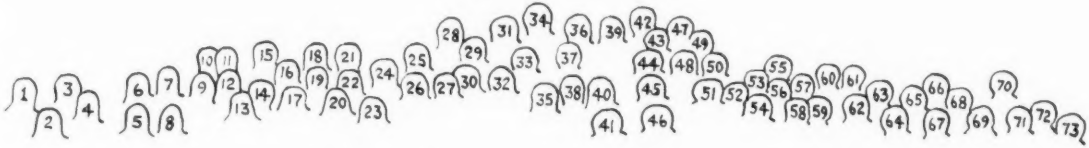
Operating the spectrograph with which magnetic fields in sunspots were first measured.

down toward the Monastery one afternoon and inquiring "where is the bar?" Fortunately we were able to supply his needs with a few bottles of beer. On another occasion, I found Küstner, who was distinguished by the broad sash he wore about his waist, standing at the foot of the 150-foot tower gazing at the steel bucket suspended by its swinging handle from a long cable. The telescope was not yet completed and the much more stable steel box of later years had not been installed. Küstner wanted to know how to go up the tower and I explained that apart from the ladder on the corner the bucket was the only means;



International Solar Union on Mount Wilson, 1910

KEY TO PHOTOGRAPH



1. Ellerman
2. H. C. Wilson
3. St. John
4. Gilmore
5. Townley
6. Slipher
7. Fowle
8. Coblentz
9. Frost
10. Idrac
11. Puiseux
12. Hartmann
13. Küstner
14. Slocum
15. Hamy
16. Knight
17. Wolfer
18. Fath
19. Rydberg
20. Hepperger
21. Fox
22. Haussmann
23. Cortie
24. Turner
25. Russell
26. Kayser
27. Adams
28. Miller
29. Ames
30. Backlund
31. Konen
32. Pickering
33. A. Fowler
34. Lampland
35. Hale
36. Belopolsky
37. Deslandres
38. Schuster
39. Campbell
40. Ricco
41. Mrs. Kapteyn
42. J. Bosler
43. Schwarzschild
44. McAdie
45. Kapteyn
46. Mrs. Fleming
47. Watson
48. Schlesinger
49. Humphreys
50. Madrill
51. J. F. Sanford
52. Chrétien
53. De La Baume Pluvinel
54. Fabry
55. Abbot
56. Hills
57. Larmor
58. Cotton
59. Dyson
60. Barnard
61. King
62. Newall
63. Pringsheim
64. Leuschner
65. Plaskett
66. Gale
67. Chant
68. Eversheim
69. Rotch
70. W. Mitchell
71. Stratton
72. Babcock
73. Ritchey

that I would, however, be glad to make the trip with him since two persons riding together would be able to balance the bucket more successfully. His sole remark was *"Ach Gott,"* and he literally vanished from sight.

One other memory I have of this meeting is of Deslandres' English. He prided himself upon his knowledge of the language and gave a long description of his spectroheliograph in English at one of the sessions. Miss Howard, who was later Dr. Millikan's secretary, served as stenographer throughout the meeting and provided the admirable transcript of the proceedings which was later published. On this occasion she came to me in considerable distress of mind. She had been unable to understand a word which Deslandres had used frequently, and without which it was impossible to gather his meaning. The word sounded like "gow," so pronounced as to rhyme with "cow." It took us some time to realize that he was describing the slit-jaws of his well-known instrument.

As the years passed, the 100-inch telescope gradually came nearer completion after many delays due to the first World War, and one night, that of November 1, 1917, it was ready for its first test. Hale, whose health was far from satisfactory, came up from the valley bringing with him the English poet Alfred Noyes, who was in California at the time. We were hopeful but none too certain about the optical performance of the telescope, since Ritchey insisted that the large mirror changed its figure with position, and had what he called "a strong and a weak diameter." Although we were reasonably sure that the effect he had observed was due to conditions in the testing hall rather than to the mirror itself, the nonhomogeneous interior of the disk was an uncertain factor. Soon after dark the telescope was swung over to the eastward and set on the planet Jupiter, and we had our first look through the great instrument. The sight appalled us, for instead of a single image we had six or seven partially overlapping images irregularly spaced and filling much of the eyepiece. It appeared as if the surface of the mirror had been distorted into a number of facets, each of which was contributing its own image. On inquiry we found that the dome had been open throughout the day while the workmen were busy with parts of the mounting, and it even seemed probable that the sun had shone, if not upon the mirror itself, at least upon the cover above it. This information cheered us up somewhat, although we were still much depressed, for our experience with the heating of mirrors by the sun had not prepared us for distortions on such a scale, and it seemed hardly possible that this could be the complete explanation. For two or three hours, however, we remained in the dome, now and then taking a look into the eyepiece. The image was changing, but the improvement was not great. To add to the gloom, news of the great disaster to the Italian army at Caporetto had just arrived, and I remember our sitting around on the floor of the dome speculating on whether Italy was completely out of the war.

Finally we decided to go back to the Monastery, but Hale and I made an engagement to meet at three o'clock in the morning at the telescope building. I doubt whether either of us slept in the interval, for we both arrived ahead of time. Jupiter was out of reach in the west, so we turned northward to the bright star Vega. With his first glimpse Hale's depression vanished: the mirror had resumed its normal figure during the long cool hours of the night, and the image of the star stood out in the eyepiece as a small sharp point of light, almost dazzling in its brilliancy. The success of this great instrument was fully assured.

In the morning we reported our experiences to Alfred Noyes. His instinct for the dramatic seized upon them, and they have become a part of his great picture of the progress of astronomical science throughout the ages, "The Watchers of the Sky."

A small gathering on Mount Wilson in 1921 deserves a word of comment because it brought together probably the most distinguished group ever to visit the Observatory. President Merriam had prevailed upon a number of the trustees of the Institution and a few others to come West together, and while here to go up the mountain. Among them were Elihu Root, Myron Herrick of Ohio, Ulysses Grant III, and General Carty, besides Merriam himself and Roswell Miller, son-in-law of Mr. Carnegie. While on the mountain the telephone rang and Herrick received the announcement of his reappointment as Ambassador to France. The most interesting feature of the visit, however, was a discussion which lasted throughout the evening between Mr. Root and Mr. Herrick on the subject of the League of Nations. Far from reporters, they spoke with the utmost freedom, and it was on this occasion that I heard the classic (but unpublished) remark by former Secretary of State Root that "Mr. Lansing was appointed Assistant Secretary of State to help fill the vacancy in the office of the Secretary of State caused by the appointment of Mr. Bryan to that position."

During the decade between 1920 and 1930, the Observatory was so fortunate as to have A. A. Michelson as an associate and active investigator. He came first to apply interference methods to the measurement of stellar diameters, and then, returning to his earliest strong interest, remeasured the velocity of light by several different methods. In both investigations he was remarkably successful, and the first determination of the diameter of a star caused a sensation in the scientific world. Michelson, however, was a physicist and not an astronomer. This is well illustrated by the story told of him by Moulton, then a colleague of his at the University of Chicago. One clear night in the winter following Michelson's measurements of Betelgeuse at Mount Wilson, the two men were walking across the university campus when Moulton stopped and pointed to a bright red star well up in the sky. "Michelson, what star is that?" said Moulton. "How the devil should I know," replied Michelson. To him a star in the sky was a point of light to feed his instrument and should be treated as such.

Michelson's new measurements of the velocity of light attracted great interest and have carried high weight in evaluations of this fundamental physical constant. He became interested in the problem while at Annapolis and would sometimes tell the story of his final examination before graduation. It seems that his interest was such that he had designed the apparatus and made some measurements while yet a student. This was known to the board of examiners. Furthermore, Michelson was not inclined to work any too hard on subjects which did not interest him, so he did not shine very brightly when questioned on various matters which the Navy considered important. After some consultation the board of examiners decided to pass Michelson, but with a warning. So one of the members of the board, according to tradition the future Admiral Bob Evans, said, "Michelson, we have decided to let you through; but if you ever expect to amount to anything in life you have got to get rid of these damned physical notions of yours."

Michelson was a fine companion on Mount Wilson, with very wide interests and a fund of stories of experiences in all parts of the world. He was a true cosmopolitan. He took up sketching and painting at about this time and, as with everything else which he undertook, did them well. Two of his Mount Wilson sketches still hang on the wall of the dining room at the Monastery.

As a matter of record it may be of interest to state that one of the discussions leading up to the gift of the 200-inch telescope took place on Mount Wilson. Dr. Wickliffe Rose, president of the General Education Board, visited the mountain when Henry Russell was there, and the three of us talked of what might be expected of a larger telescope, its administration, and how it might be given. Rose took the part simply of an interested layman and not that of the head of a great foundation, and so we could all speak freely of what was in our minds. Russell and I agreed that the fundamental question was that of obtaining the telescope and having it operated to the best advantage, while the question of the recipient of the gift was secondary and one for the donor to settle. In later years I have often thought of this discussion and of the deep interest which Dr. Rose showed in all its phases.

In looking backward over the earlier years of the history of the Observatory, I am impressed more and more by the greatness of the figure of Hale, without whom it is doubtful whether the Observatory, if established at all, could ever have attained its high position in the field of astronomy. For the early years were difficult years filled with uncertainties, and it took great courage to start at the very beginning and, as time passed by, to face the responsibility for sponsoring such costly and sometimes unpredictable instruments as the 60-inch, 100-inch, and 200-inch telescopes. A lesser man with less creative imagination would have been satisfied with more conservative equipment which he might himself use, but Hale planned for a future in which he had long realized he could take no active part. We can rejoice that he lived to see the

success of these great plans assured. As one who was associated with him from the beginning, I can but express my feeling of the greatness of the privilege allowed me in our long period of association together.

Astronomy at Washington and Jefferson College before 1900

By RAYMOND M. BELL

Beginnings

Jefferson College was founded at Canonsburg, Pennsylvania, in 1802; Washington College in 1806 at Washington, Pennsylvania, seven miles south of Canonsburg. These colleges united in 1865 to form Washington and Jefferson College at Washington, Pennsylvania. Astronomy was generally taught by the Professors of Natural Philosophy and Mathematics. The Washington and Jefferson Library possesses copies of Fleming's "A New System of Astronomy" printed in 1786 and of Ferguson's "Astronomy" printed in 1790. These belonged to the Washington College library as early as 1824. A copy of Ewing's "Practical Astronomy," 1812, was acquired by Washington College in 1828. The Washington College catalogue for 1824 does not list Astronomy as one of the courses. The next catalogue available, 1836, describes a course in Astronomy. It was likely first taught at Washington College by William P. Alrich, who was Professor of Natural Philosophy and Mathematics from 1830 to 1860. Alrich was a Presbyterian minister at a country church near Washington. He was responsible for the purchase of the first telescope.

On April 8, 1839, the trustees of Washington College resolved "that a sum not exceeding two hundred dollars be appropriated for the purchase of a Telescope for the use of the College." On September 24 of the same year it was reported:

> That an instrument had been procured at an expense of 225 dollars and the cost of transportation. It was Resolved That the treasurer be directed to pay the Rev. Amak (?) Holcomb, of Southwick, Hampshire County, Massachusetts, 225 dollars on account of the Telescope.

At that time Professor Alrich's salary was $820.

This telescope was used for many years. On September 17, 1859, Professor Alrich writing at Washington, Pennsylvania, directed a letter to the President of the Board of Trustees:

> Our present telescope was at the time it was purchased among the best of those found in Colleges in this and other portions of the Western Country: But the improvements made in instruments of this kind, are so great, and the price so much reduced within a few years, that ours, now stands far behind those around us. Often

> those owned by individuals for private use are superior: this is the case with one in this town.

He asked for a new telescope. The trustees appropriated $50 for astronomical equipment. No details are available on the 1839 telescope. It disappeared many years ago.

Many of the early books in the Jefferson College library have been lost, but the earliest catalogue, 1827, lists Astronomy as a required Junior course. It was likely taught from the beginning of the college in 1802. In 1834 Astronomy was made a Senior course. In 1841 Herschel's "Astronomy" was used as the text. The Jefferson professors who taught Astronomy were: 1802-1830 Samuel Miller; 1830-1838 John H. Kennedy; 1838-1841 William Darby; 1841-1843 Richard S. McCulloh; 1843-1854 Samuel R. Williams; 1855-1862 John Fraser. Miller, Kennedy, and McCulloh were Professors of Natural Philosophy and Mathematics; Williams of Natural Philosophy and Chemistry. Darby, famous as a geographer, lived in Washington, Pennsylvania. He was Professor of "History, Geography, and Astronomy." Fraser filled the chair of Mathematics and Astronomy.

In 1850 Jefferson College had 185 students, of which 60 were Seniors. Washington College had 113 students, 37 Seniors.

Chair of Mathematics and Astronomy

In 1855 John Fraser was elected Professor of Mathematics at Jefferson College. He arrived at Canonsburg on April 18, 1855. An interesting account of his life is given by Wightman in "A History of the Jefferson College Class of 1860." Fraser was born in Cromarty, Scotland, about 1823. He was graduated from the University of Aberdeen in 1850, winning the Huttonian prize in mathematics. Wightman wrote:

> He had native ability of the highest order and genius that ranked him with the very few. His attainments in breadth and richness were such as only men of his caliber can make. In the Greek and Roman classics he was thoroughly at home. Of the physical sciences, enlarging the meaning of the term so as to include geology and astronomy, he was easily master. He knew his Plato and Aristotle. . . Of men's best thoughts, from literature both ancient and modern, his mind was richly stored, and he was himself a thinker of the most discriminating kind.

On August 4, 1857, a new Chair of Mathematics and Astronomy was established by the Trustees of Jefferson College and $100 appropriated toward the purchase of a telescope. Fraser became this new Professor. The catalogue for 1857-1858 says:

> To facilitate the study of this science a powerful Refracting Telescope, equatorially mounted and moved by clock-work, together with a Micrometer and other valuable instruments have been purchased during the past year.

This telescope had an eight-inch objective. The length of the instrument was 9½ feet. It was made by Alvan Clark and Son. The price was $183. Today only the objective lens remains. At that time Harvard possessed the largest telescope—22 inches.

Mr. Boyd Crumrine of the Class of 1860 gave his complete 101 page notebook on Fraser's course to the Washington and Jefferson Library. It contains 226 sections.

Fraser in 1862 entered the Union Army as a Captain. In 1865 he was mustered out as a Brigadier General. During his absence A. J. Caldwell taught Astronomy. On June 21, 1865, he was elected Professor of Mathematics and Astronomy by the Board of Trustees of the new Washington and Jefferson College. On August 1 he declined, for he had accepted an appointment at what is now The Pennsylvania State College as Professor of Mathematics and Military Tactics.

Fraser was President of Penn State 1866-1868; Chancellor of the University of Kansas 1868-1874; State Superintendent of Schools, Kansas 1874-1876. In 1876 he was made Professor at what is now the University of Pittsburgh, where he died of smallpox in 1878.

Daniel Kirkwood

The fact that many of Jefferson College's students were from the South was one of the factors that led to the union in 1865 of the two colleges into Washington and Jefferson College. For several years classes were conducted at both Canonsburg and Washington. The scientific work was left at Canonsburg in 1865.

Daniel Kirkwood
(About 1867)

Observatory
(About 1900)

On August 2, 1865, the Minutes of the Board of Trustees record:

> The Committee to procure a Professor of Mathematics and Astronomy for the Department at Canonsburg nominated Daniel Kirkwood LL.D. now Professor in the University of Indiana.

On December 20, 1865, a letter of acceptance from Dr. Kirkwood was reported to the trustees.

Kirkwood was born in Maryland in 1814 and died in California in 1895. He taught at Indiana University 1856 to 1886, except for his two years at Canonsburg. Kirkwood is still recognized for his work connecting meteor streams and comets. His book on "Meteoric Astronomy" was published in 1867, the preface written at Canonsburg, May, 1867. Loomis was the text Kirkwood used in his classes.

On July 31, 1867, the action of the Board of Trustees was:

> That Prof. Kirkwood be authorized to make such alterations in the room on the first floor and in the southwestern corner of the old College building at Canonsburg, as may be necessary to fit it for the use of the telescope.

On August 19, 1867, Kirkwood wrote to the President of the Board:

> I have been notified that on the 14 inst. at a called meeting of the board of trustees of Indiana University I was reelected to the Chair of Mathematics at a salary of $1600. It is earnestly desired by the trustees and faculty that I should accept, and be ready to commence my duties there at the opening of the next term, Sept. 17. . . I think duty to my family renders my acceptance necessary. . . I came here under a sense of duty, expecting to remain.

Kirkwood asked that the rule requiring three months' notice be waived. Apparently this was not done, for his resignation was not accepted until December 18, 1867.

Washington and Jefferson College was a new and struggling college in 1867. Indiana offered Kirkwood twice as much salary. In April he had been asked to help teach Greek Testament and Bible. No doubt there were better facilities at Bloomington.

Following Kirkwood, Astronomy was taught by Rev. John S. Roberts 1867-1868; James S. Simonton 1868-1871 (who transferred to Modern Languages); and George B. Vose 1871-1873 (who also taught Mechanics).

Observatory

In 1873 Dunlap ("Tangent") J. McAdam, of the Class of 1868, began to teach Astronomy. For many years he was Professor of Applied Mathematics. He was born in Ohio in 1843. He died in Washington, Pennsylvania, in 1925, eleven years after retiring.

When the scientific work and equipment was moved to Washington about 1870, it was found that the telescope objective lens was missing. It was not recovered until 1879. Its recovery spurred Professor McAdam to make plans for an observatory. In the 1870's the college had acquired a four-inch refracting telescope made by "H. Fitz, New York." Fitz made telescopes between 1863 and 1884 according to a recent letter from Mr. Harold B. Webb of Lynbrook, New York. This Fitz telescope is still in use; it is in very good condition.

The college paper (Washington Jeffersonian) in March, 1882, reported that owing to Professor McAdam's efforts a college observatory was to be built between the main college building and the Union School. McAdam wrote to the President of the College on June 20, 1886:

> As reported at your last meeting nearly $1000 have been subscribed for the purpose of building an Observatory. The four-inch equatorial is very conveniently mounted in its own building. Work has been commenced on the new building. In order not to expend more than has been raised, the room for the larger equatorial is all that has been commenced. It is to be of brick. Is octagonal in shape, 20 feet across, 2 stories in height, being 34 feet from the ground to the top of dome.

He hoped later to add on the west a room 16 x 18 for a transit, clock, and chronograph. This was done, but a second room 16 x 18 for computing was never built.

The college paper in June, 1882, said that the observatory was a fact. The inside of the dome was circular. The eight-inch Alvan Clark was clock driven. The College Catalogue for 1882-1883 tells about the observatory. Extensive plans were made for the March 16, 1885, eclipse, but bad weather interfered.

In 1891 erection of a college gymnasium was begun. Since the site chosen was where the observatory stood, it was necessary to move the observatory. The new site was on an acre of land on a hill-top, 0.7 miles northeast of the campus (now North Wade Avenue). The octagonal section was rebuilt as circular. The catalogue for 1891-1892 tells of this. On December 23, 1891, the College President reported to the Trustees that the rebuilding of the observatory was nearly complete.

The observatory was not used much after 1905. By 1914 it had disappeared. McAdam taught Astronomy 1873 to 1914, when he retired. He was succeeded by Dr. O. F. H. Bert, who retired in 1948. McAdam and Bert together taught Astronomy for a period of 75 years.

All of the above information was taken from the W. & J. College Historical Collections, of which Mr. Charles M. Ewing is Director.

Denver's Chinese Sundial

By GEORGE E. CRANMER

About forty years ago, Mayor Speer acquired land for a system of boulevards on the East side of Denver. He purchased twenty acres of ground on the highest point in this boulevard area from which the view of the Front Range of the Rockies is superb. Accented with four peaks over fourteen thousand feet in altitude, the view covers about one hundred and fifty miles from Pike's Peak on the South to the Mummy Range near the Wyoming line on the North.

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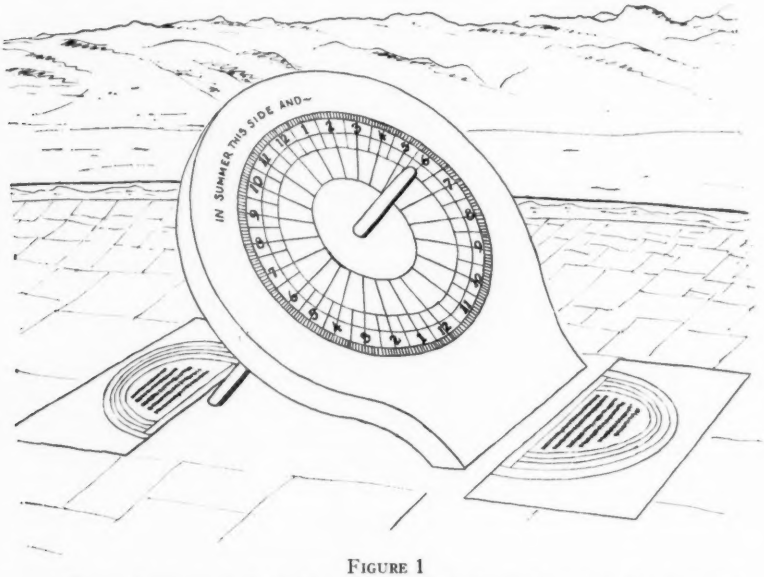

FIGURE 1

The analemma was divided into two half circles and cut into the pavement. Within these half circles are also instructions for reading the sundial by using the upper edge of the shadow and, with the date on the analemma, making the addition or subtraction from sun time to get watch time.

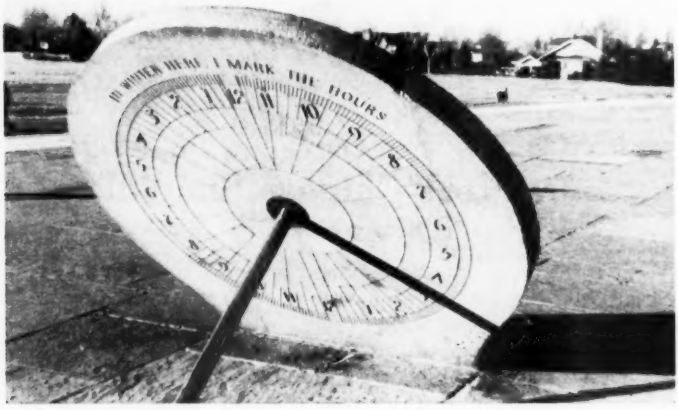

FIGURE 2

During the depression, it was my job, as Manager of Improvements and Parks for the city, to find useful work for ten thousand WPA workers. The development of this twenty-acre park seemed to me a desirable project.

For the highest point, I designed a viewing platform about two hundred feet long, built and paved with red sandstone. On the western edge of this we put a picture of the mountains two hundred feet long in terrazza with the names and altitudes of the prominent peaks. To break up the monotony of such a large platform and to add interest, a sundial in the center seemed desirable. Most sundials are complicated, expensive, and not sufficiently rugged for public use. The site seemed to require something simple, strong, and monumental. While this problem was very much in mind, I was traveling in California and, being interested in Oriental art, I visited the Chinese garden of Marsh & Co. in Monterey where I saw an old Chinese sundial in white marble on a marble pedestal. The circular stone was about six inches in diameter and pierced through the center by a slender bronze bar. Its simplicity and attractive form immediately appealed to me. The management permitted me to take photographs and rulings which I brought back to Denver and submitted to Mr. Stephen Ionides, an astronomer and sundial enthusiast, engineer, and author. He was immediately interested and said he thought my plan of making a similar sundial with a stone six feet in diameter was very practical; so I employed him to make the designs and supervise the setting. These things he did in a very expert and efficient manner.

The large, circular slab of hard red sandstone came from Lyons, Colorado, about forty miles Northwest of Denver. It is five and one-half inches thick and extends about two feet below the stone pavement into the foundation. This stone slab is elevated 50° 43′ and set parallel to the equator. It is pierced through the center with a solid, stainless steel bar elevated 39° 17′ which is our North latitude. This bar is three inches in diameter and about seven feet long. The lower end penetrates the pavement. The bar points to the pole of the heavens near the North Star.

Mr. Ionides called my attention to the fact that the movement of the shadow of the upper edge of the stone on the bar from day to day would mark the date at noon each day if the necessary gradations were made on the bar. I asked him to lay out the gradations for the dates, which he did, but we neglected to place them on the bar. Recently, in the provincial museum in Toronto, Canada, I noticed a small bronze sundial of this type with gradations to show the date. This renewed my interest and I am now seeking a method of putting the date layout on the steel bar. Mr. Ionides also designed an analemma divided in two semicircles with instructions as to how to use it and an explanation of our latitude and longitude. This divided analemma is incised in two

pavement stones, one directly North and the other directly South of the sundial.

Since the sundial is only seventeen seconds of time East of the 105th Meridian on which Mountain Time is based, and since the whole setting is so accurate, one can set his watch by it.

200 Cherry Street, Denver, Colorado.

Schmidt Correction Plates

By J. GRINDROD, B.A.

About twenty years ago in the village of Bergedorf in Germany, near the Hamburg Observatory, an instrument-maker, connected with the Observatory, whose name was Bernhard Schmidt, was struggling with a problem. He knew of the difficulties connected with the photographing of the constellations and had devoted many years of thought to the problems of correcting the main aberrations which became apparent when trying to photograph the stars without loss of light.

Of the various aberrations that occur when images are reproduced or reflected with the aid of mirrors or lenses that of spherical aberration is most important. These blurred images occur when the light rays emitted from one point and passing through a lens cannot be re-united at a single point at the back of the lens. It is usually the rays at the edges of the beam that fall short. They find positions behind the lens at points on the optical axis that differ from that of the rays at the centre of the beam, which are at smaller angles to the optical axis.

There are other aberrations, but it is perhaps sufficient to say, in general, that nowadays they can all be calculated mathematically. This does not mean, however, that a system has been evolved which will eliminate all aberrations. In fact it can be shown mathematically that such a system is impossible.

Spherical aberration has been overcome by the use of a diaphragm, an opaque object with aperture often adjustable and usually in the centre.

Placing the diaphragm in front of the lens has the effect of permitting only those rays to pass through the narrow opening of the screen which lie in the neighborhood of the optical axis. The rays at the periphery of the beam are excluded, and, in consequence, those which pass through concentrate behind the lens at one spot and form a sharp image.

The use of the diaphragm, however, limits the quantity of light which passes through the lens, and because of this the image is normally weaker. In the case of photography the image may be underexposed unless bright sunlight or a strong artificial light source is used. For most ordinary needs, modern photographic material and the high standard of perfection of present artificial light sources have removed

all difficulties once connected with the loss of light due to the use of a diaphragm. In certain fields of photography, however, the correction of aberrations at the expense of sufficient light has provided scientists with very definite problems. This applies when photography has to record things that cannot be reached with artificial light, however strong.

The part that photography plays in modern astronomy is, for instance, one of the fields in which great difficulties still existed in spite of the use of a diaphragm. This is so especially when the astronomer wishes to record a nebula or other object that emits only very weak light. It still meant that very long exposures of the sensitive plate had to be made—that is, until, in 1931, B. Schmidt suceeded in designing the optical system that is now named after him. An essential part of that system is the so-called correction plate.

Schmidt, in the first place, used a spherical concave mirror. The concave mirror offers at once two advantages: the mirror is entirely free of colour aberrations while the spherical aberration is, under certain conditions, only one-eighth of that obtaining when a simple lens is used. He also used a diaphragm into which he placed his correction plate. The latter consisted of a glass plate of varying thickness which had the effect of breaking each ray of light a little differently as though each was individually being transmitted through a prism. The diffraction occurred in such a way that just that deflection was obtained which would correct the aberration. The result was that the diaphragm opening could be made so much larger without the danger of spherical aberration and greater quantities of light could be used.

The method adopted by the Hamburg craftsman for the making of his correction plate was made public after his death in 1935. The manufacture of these plates, however, proved very laborious. The difficult and individual finishing-off process made it seem that it would be imposible to manufacture them on any large scale.

Schmidt's first spherical mirror with correction plate was used at the Hamburg Observatory. A number were ground by hand for individual telescopes and, indeed, by 1941 there were already 44 observatories each with a Schmidt camera, manufactured at great expense and under considerable difficulties. These cameras with their excellent sensitivity and their large field of vision have proved of great use.

But the difficulties of production had still to be overcome. When it was realized, also, that the correction plate would solve reproduction problems in other fields, such as television and the recording of X-ray images on the fluorescent screen, investigations were started to see whether they could not be manufactured by simpler methods.

With the immense strides made by plastics, opticians and optical instrument-makers asked themselves whether or not correction plates could not be made out of this pressed material, and in the United States plastic correction plates have been made and used. A mould is made

of the form required and some kind of transparent plastic, *e.g.*, polystyrene, is pressed into it. The mould has to be made very accurately and must have a surface of optical qualities. Thus not only must the mould faithfully follow the remarkable curvature of the correction plate but even the slightest errors, roughnesses, and cracks have to be avoided. The surface must also be able to stand up to pressing and heat treatment with a result that the choice of material that can be used is very limited. The mould is usually made entirely by hand then polished and carefully finished. A separate mould is required for every shape of the correction plate.

Polystyrene is a plastic possessing amazing clarity and optical properties and is highly resistant to moisture.

In spite of the precision and care with which the moulds have to be made the manufacture of plastic plates is a great improvement over that of the glass plates. In Holland other ideas were pursued and an entirely new method of manufacturing correction plates has been worked out at the laboratories of N. V. Philips Gloeilampenfabrieken at Eindhoven, which involves the use of gelatine.

A metal mould is made on a precision lathe, the shape of the surface being the negative of the required correction plate. This mould has diagonally the same dimensions as the correction plate but it is five times as thick. For instance, if the total variation in the thickness of the actual correction plate is 0.5 mm. then that of the mould will be 2.5 mm.

The carefully finished and polished mould is heated to about 40° C. by running hot water. A gelatine solution is then poured out on to the mould and this is covered by a glass plate. By means of adjusting screws the plate is brought to within a short distance of the surface of the mould. This causes the superfluous gelatine to be pressed away. Cold water is then passed through the mould until it cools off completely and the gelatine solution changes into a solid mass. The glass plate is then unscrewed and taken off the mould. The gelatine thereupon shows all the details of the mould.

Formalin vapour is used to harden the gelatine skin which is dried uniformly. As the gelatine is kept laterally rigid by means of the glass plate it will shrink only in its thickness. The original surface is thus reduced in only one direction; the remainder is unchanged.

A thin layer of gelatine is left on the glass plate after the drying process which is five-fold reduction of the surface of the mould. The surprising part is that the shrinkage occurs so uniformly and so accurately. A very smooth surface is obtained with every detail of the mould reduced five times but otherwise unchanged. The hardened gelatine appears to be stable but it may be desirable to cover the curved surface of the correction plate with a second glass plate to avoid the gelatine being impaired by wet fingers or drops of moisture.

This gelatine method of manufacturing correction plates has a num-

ber of advantages over other methods so far followed. The mould need be only one-fifth as accurate as those used with plastics as the five-fold reduction of the jelly will reduce errors to one-fifth. Fine scratches in the mould are no longer objection as they are reduced to one-fifth their thickness during the cooling and drying process of the gelatine. In many cases their depth will be less than the wavelength of the light.

A second advantage is that moderate heating and cooling of the mould is sufficient. As no pressing is required, no distortion will occur.

Thirdly there is no deformation or mechanical bending of the plate as it consists mostly of glass. The hard gelatine layer is resistant to scratches so there is no objection to cleaning the plate with a soft cloth.

Fourthly the same mould can be used for the manufacture of correction plates of different optical strength—varying concentrations of the gelatine solution will produce correction plates of different optical strengths.

The invention of Schmidt and its practical development now make it possible to obtain a large and useful field of vision with sharpness of image even at the extreme edges of the photograph, and excellent results have been achieved in photographing the night skies by this method.

Fern Cottage, Harleston, Norfolk, England.

Fun with a Solar Globe

By WALTER L. MOORE

A surplus lens with a strongly curved field furnished the first inspiration for a sphere upon which to project the image of the sun. This sphere followed in general design one reported by Heines in the July, 1937, issue of Popular Astronomy. Some modifications were necessary as it was to be mounted on a projection frame already constructed for the 12-inch Clark reflector.

Three months of plotting spots on the globe has already demonstrated its usefulness in confirming the shift of long-lived spot groups both in longitude and latitude, in determining latitude of groups close to the equator, in measuring the orientation of the axis of bipolar groups and in finding areas of disturbances on the surface of the sun. The determination of latitude and longitude is affected by the lateral magnification of the projection lens. A study of the amount of this error is one of the projects scheduled for the near future.

The globe was constructed from two Wilson hemispheres. This choice was made because of the spherical protractor in the set. This made unnecessary the construction of meridians and circles of latitude on the sphere itself. A clear surface is more suitable to the detection of small spots than is one on which circles are drawn. Three graduated dials were installed, one on the axis of the globe giving a reading of the

longitude of the center of the disc, one on a meridian giving the latitude of the center, and one perpendicular to the optical axis of the telescope making possible the measurement of the position angle of the axis of the globe. The data for these settings are obtained from the *American Ephemeris.*

The program calls for the recording of spot groups and their serial numbers until no more room is found for a legible record. In this way it is hoped to verify other studies of the distribution of areas of activity on the total surface of the sun. That spot groups tend to recur in certain areas also was indicated in a term paper made by a student at the University of Louisville from data collected for the last three years for the solar program. Mr. Humkey's graph of daily sunspot numbers in both northern and southern hemispheres shows periodicities which seem to indicate recurrence of groups in the same place. Such areas should show up even better on the globe.

One result of Mr. Humkey's study that is probably of little interest to anyone except the observer is the good agreement between the Zürich spot numbers and those of the observer.

University of Louisville, Kentucky.

The Planets in April, 1950

By RAYMOND H. WILSON, JR.

Note: The time employed is Central Standard Time unless otherwise indicated. The phenomena have been chosen and described for the North American continent, and especially for the United States. The basic data have been taken principally from the *American Ephemeris and Nautical Almanac.*

Sun. During the month the sun will move northward from 4 degrees to nearly 15 degrees north declination. This latter position will result in a sunlight intensity equivalent to that of the middle of August.

Moon. The phases of the moon will occur as follows:

Full Moon	April	2	3 P.M.
Last Quarter		9	6 A.M.
New Moon		17	2 A.M.
First Quarter		25	5 A.M.

The moon will be at perigee on April 3.

An occultation of Spica may be visible along the northeast coast on April 30 at 6 P.M., E.S.T. On the other hand, only the west coast will see the Pleiades occulted on April 19, just before 7 P.M., P.S.T.

Evening and Morning Stars. Saturn and Mars will appear in the eastern evening sky, while Jupiter and Venus will shine brilliantly in the southeastern dawn.

Mercury. The latter half of this month will be the most favorable season of the year for viewing Mercury in the evening sky. It will be 20 degrees northeast of the sun on April 22.

Venus. Venus will be at its maximum elongation of more than 46 degrees west of the sun on April 11. Although its southern declination will be unfavorable, it will be rising before 4 A.M.

Mars. Having just passed opposition, Mars will be conveniently situated for evening observation at a point about half way between Regulus and Spica. On the 28th it will be only a degree north of the waning moon.

Jupiter. Again, during the first half of this month, Jupiter will be accompanied by the brighter Venus, which will pass 2 degrees north of it on the 5th. On April 12 the moon will also join this conspicuous group.

Saturn. Situated in Leo a few degrees east of Regulus, Saturn will be most favorably situated for early evening observation. On April 28, shortly after midnight, the moon will pass only a few minutes of arc south of the planet.

Uranus. Uranus will be moving slowly eastward at about a degree east-northeast of 1 Geminorum.

Neptune. Neptune will be moving northwestward at a point about 2 degrees west-northwest of θ Virginis.

Department of Mathematics, Temple University, Philadelphia, Pa.
February 2, 1950.

Asteroid Notes

By HUGH S. RICE

We offer the following four sets of positions for the brightest minor planets next to come to opposition after those we have given previously. These are taken from the minor-planet data published in the U. S.; the positions given in the Russian book are very similar, except that in the latter, Amherstia (for March 20 for example) has a right ascension 10^m greater, and a declination 1° 22′ greater or more southerly. The opposition photo-magnitudes of planets 5, 532, 516, and 8 are, respectively, 9.0, 8.7, 9.3, and 9.7; but the corresponding visual magnitudes are likely a large fraction of a magnitude brighter.

ASTEROID EPHEMERIDES

0^h U.T. Equinox 1950

5 ASTRAEA

1950	α h m	δ ° ′
Mar. 10	12 10.3	+ 4 44
20	12 2.5	+ 6 7
30	12 54.7	+ 7 21
Apr. 9	11 48.3	+ 8 17
19	1 43.9	+ 8 47

532 HERCULINA

1950	α h m	δ ° ′
Mar. 10	12 31.1	+24 49
20	12 24.0	+26 23
30	12 16.3	+27 25
Apr. 9	12 9.1	+27 49
19	12 3.6	+27 34

516 AMHERSTIA

1950	α h m	δ ° ′
Mar. 10	12 51.6	—20 21
20	12 43.9	—21 42
30	12 34.1	—22 37
Apr. 9	12 23.5	—23 5
19	12 13.6	—23 8
29	12 6.1	—22 50

8 FLORA

1950	α h m	δ ° ′
Mar. 10	12 54.6	+ 3 59
20	12 46.2	+ 5 15
30	12 36.4	+ 6 27
Apr. 9	12 26.6	+ 7 27
19	12 18.3	+ 8 8
29	12 12.9	+ 8 25

Hayden Planetarium, American Museum of Natural History, New York,
1950 February 21.

Occultation Predictions for April, 1950

(Taken from the *American Ephemeris*)

The quantities in the columns *a* and *b* are given for the purpose of making these predictions useful for any place within 200 miles of the point indicated. The procedure is as follows: Subtract the longitude of the point given from the longitude of the place in question; multiply the result in degrees, taking the signs into account, by the quantity under *a* for the star to be observed; similarly, with the latitude, using *b*; apply the sum of the products, with its proper sign, to the Greenwich C.T., and obtain the predicted Greenwich Civil Time for the phenomenon at the place of observation. To obtain Eastern Standard Time it is necessary to subtract five hours; Central Standard Time, six hours, etc.

			IMMERSION				EMERSION			
Date 1950	Star	Mag.	Greenwich C.T.	*a*	*b*	Angle E from N	Greenwich C.T.	*a*	*b*	Angle E from N
			h m	m	m	°	h m	m	m	°
	OCCULTATIONS VISIBLE IN LONGITUDE +72° 30′, LATITUDE +42° 30′									
Apr. 4	214 G.Virg	6.4	6 29.7	−0.6	−1.7	167	7 23.0	−2.2	−0.5	262
5	47 G.Libr	6.1	7 1.1	−1.8	−0.2	99	8 12.8	−1.4	−1.2	315
6	48 B.Scor	5.1	4 7.2	−0.5	+0.6	114	5 11.2	−0.8	+0.4	296
6	65 B.Scor	5.6	6 29.4	−1.5	+0.3	109	7 44.4	−1.6	−0.3	296
30	α Virg	1.2	23 15.5	..	..	192	23 37.0	..	..	234
	OCCULTATIONS VISIBLE IN LONGITUDE +91° 0′, LATITUDE +40° 0′									
Apr. 5	47 G.Libr	6.1	6 34.6	−1.0	−0.3	133	7 45.7	−1.7	−0.2	289
6	65 B.Scor	5.6	6 13.1	−0.3	−0.3	145	7 12.7	−1.7	+0.9	265
25	λ Canc	5.9	4 40.9	−1.5	−0.1	55	5 17.5	+1.1	−3.1	355
29	BD+1°2624	6.4	7 48.5	−0.4	−1.8	134	8 46.0	−0.2	−1.7	290
	OCCULTATIONS VISIBLE IN LONGITUDE +98° 0′, LATITUDE +31° 0′									
Apr. 1	σ Leon	4.1	4 9.0	−3.5	+1.6	76	4 51.5	+0.5	−4.0	9
5	47 G.Libr	6.1	6 40.0	+0.3	−2.1	173	7 27.3	−2.9	+1.2	254
9	234 B.Sgtr	5.9	8 9.3	−1.2	+2.0	57	9 8.1	−0.6	0.0	303
25	λ Canc	5.9	4 46.0	−0.8	−1.1	93	5 43.5	+0.3	−2.1	320
29	BD+1°2624	6.4	8 3.8	−0.4	−2.2	154	8 56.0	−0.5	−1.2	274
30	319 B.Virg	6.3	8 34.0	..	..	52	8 58.0	..	..	10
	OCCULTATIONS VISIBLE IN LONGITUDE +120° 0′, LATITUDE +36° 0′									
Apr. 1	σ Leon	4.1	3 27.3	−1.4	+0.9	97	4 28.0	−0.8	−1.7	336
4	40 H.Virg	5.1	7 45.4	−2.3	+0.8	88	8 41.6	−0.5	−1.7	346
20	25 Taur	4.2	2 58.9	−0.6	−0.4	66	4 0.2	+0.2	−1.5	279
20	η Taur	3.0	3 46.7	−0.9	+1.0	31	4 24.0	+1.0	−2.9	315
23	49 Auri	5.0	6 57.3	−0.2	−0.4	59	7 36.7	+1.0	−2.0	325
25	λ Canc	5.9	4 14.2	−1.2	−1.8	122	5 28.7	−0.9	−1.9	294
28	χ Leon	4.7	8 40.5	−0.7	−1.4	105	9 38.2	−0.1	−2.0	322
29	β Virg	3.8	4 31.9	−2.6	+0.4	91	5 28.9	−0.3	−2.6	353
29	BD+1°2624	6.4	7 43.8	0.0	−2.9	179	8 27.4	−2.0	−0.9	259
30	319 B.Virg	6.3	7 42.1	−2.3	−0.5	86	8 37.0	−0.5	−2.4	349

METEORS AND METEORITES

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVER, President

The first section of these Notes consists of a very interesting article published in Vol. LIX, No. 3, pages 459 to 462, of the Academy of Sciences of the U.S.S.R., by E. L. Krinov. As the journal is not available to most people in America, and,

even when it is, few can read Russian, I was fortunate in having my friend, Dr. Walter Grigaitis, Conductor of the Polish Paderewski Orchestra, who was a former student at the Imperial University in St. Petersburg and is now a member of the Rittenhouse Astronomical Society here, offer to translate it for me. His translation, with slight changes, follows. It will be seen that, assuming the full accuracy of the original account, we have in this the greatest of all witnessed falls, either of iron or stone meteorites. It is a matter, as usual, of most profound regret that, so far as known, no foreign scientist has been invited or been allowed to visit the area in question. As this was similarly true for the area in Siberia of the great fall of 1908 June 30, during the 1920's and 1930's when the U.S.S.R. was far more open to travel than today, there is no cause for surprise but only for regret in this prohibition. After reading the article very carefully, it does seem to me that a convincing argument has not been made for the statement that "the meteorite shower was formed in the atmosphere from one great mass," which broke up. True, there may be much more evidence not given in this article, and certainly more details were known to the scientists who studied the area where the fall took place. If these were fully explained, probably Krinov's conclusion would be clearer. Again with the vast number of fragments said to have been recovered, none so far is known to have been sent to any foreign museum or scientist for study. Incidentally, as two great falls have taken place in Siberia within 32 years of one another, one may wonder whether there may not have been others in very recent times which fell into the oceans, polar regions, or other uninhabited regions. At any rate such phenomena are of current and not mere historical interest.

Some Peculiar Characteristics of the Meteorite Fall in Sikhote-Alinsk

presented by S. I. Vavilov, member of the Science Academy in Soviet Russia

E. L. Krinov

February 12, about 10:35 A.M. (according to local time) in Sikhote-Alinsk ($\phi = 49° 10'$; $\lambda = 104° 19'$ from Pulkovo, geographical co-ordinates 134° 39.7 east, 46° 9.6 north) there was an unusual iron meteorite fall, accompanied by optical and acoustical displays. From the material gathered by the author, a member of the investigating committee, several conclusions can be drawn from this rare meteorite fall.

In the first place, the author states that it is the largest and the heaviest iron meteorite fall in the world.

The study of this fall reveals the ellipse of the fall and permits one to draw a conclusion of certain peculiarities of the structure of meteorites. The first to be noted is the considerable smallness of the area of the ellipse, about 7 x 8 square kilometers, length of the longer axis about 5 km., pointing north—azimuth 344° from N. to E. It was noticeable that the western part and the southern part of the ellipse are full contoured; the eastern and northern parts are drawn at random.

The second peculiarity of the ellipse of this fall is its deviation from the usual symmetry of the meteorite fall and the division of the meteorite mass.

The whole area of the ellipse is divided in two parts: the head part about 0.75 sq. km. where the heaviest masses fell, and the lower part with the larger area. In the head part were found 106 craters with diameters from 0.6 to 28 m., 21 craters were of 10 m. in diameter, 18

craters were from 3 to 10 m. in diameter. The craters are spread irregularly and often alongside of the largest one the smallest is located. The study of these craters shows a radical difference from other meteorite craters. The details of this fall were described by W. G. Fessenkoff in *Sternenwelt*, August, 1948.

In the craters or between them were found many meteorite fragments weighing from a milligram to hundred kilograms. On the outside they resemble fragments from meteorite craters of Canyon-Diablo and Henbury (Australia) and also separate samples of Chinghe (Russia). In the majority of cases the fragments have a squeezed-in form, or often S-shaped or flat surfaces with jagged, sharp endings often with long thin sticks.

Between the breaks in larger pieces can be seen separate beams and in general octahedron structure. As a rule fragments are covered by rust and clay, often forming grape-vine formations of "laurencite" and on the bent-in surfaces coating of intensive blue or rainbow colors.

Characteristic of some fragments are also signs of deformations resulting from the fall on rocks in the shape of scars, deep breaks, etc.

With the help of hand magnets were secured from clay and pieces of porphyry the smallest fragments of meteorites.

From two craters in diameter 0.6 m. were extracted large meteorites weighing 68.7 and 84.8 kilograms.

From larger craters in diameter 2.6 and 2.8 m., we extracted meteorites weighing about 300 kg. each.

In one case the meteorite had many fissures and crevices, in another the meteorite was broken in 4 large chunks; it was possible to put together those fragments restoring the original shape of the meteorite.

From the partial opening of one crater of 23 m. under the surface of debris from 0.5 to 1 m. was found a layer of porphyry but no large meteorites—only small fragments mixed with clay and pieces of porphyry.

Measurements from the bottom of craters in the direction of trees, broken during the meteorites fall (an average of 18) gave azimuth 359°, and an angle 30° (from normal).

In the lower part of the ellipse were gathered 257 samples, weighing from one milligram to 300 kg.

The smallest fragment weighs 0.18 gr. and has the size of 3x4x5 mm. It is perhaps the smallest iron meteorite in the world. Samples of 1 to 2 kilograms were found on the forest's surface and only seldom were buried in the ground. Larger samples were lying in the small ditches, sometimes open, sometimes covered by layers of earth. In some cases meteorites were found near their ditches. Often were noticed branches cut by falling meteorites.

Directional measurements of the fall of meteorites in reference to the place of the fall gave azimuth 357° and angle 27°. General spread of the meteorites in the ellipse shows a sharp concentration of the material in two main points.

In most cases the individual fragments have irregular form and a peculiar beam-grained structure, never before noted anywhere in iron meteorites. Often are seen separate beams sticking out (see Figure 1) and they are usually parallel with each other or crossing each other at the angle of 60°. Often can be seen flat triangle surfaces presenting grain

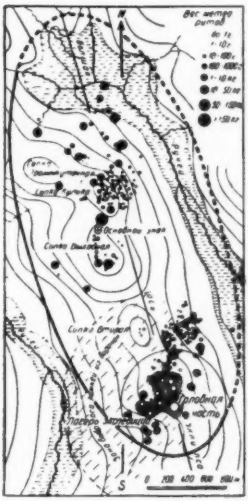

FIGURE 1

of octahedrite alongside of which evidently meteorite broke up during the fall. Crossing each other they form angles of 60°. Amazingly distinct are a number of Widmanstatten lines on the flat surfaces of some of the meteorites which are due to the abundance of beams and rib-like projections.

Second characteristic peculiarity of individual samples are deep worm-like crevices and fissures formed by large pieces of *troilite,* often seen on the surfaces or when meteorite is sawed in two.

Many samples show certain elements of orientation besides. On the front surfaces the top layer shows shriveled, wrinkled structure forming its own design. On the other side the top layer is porous and on the sides can be seen little clusters. On many samples, even of small size, can be seen many fissures and crevices formed as they fell upon the rocks.

Study of the interior structure of the meteorites revealed the fact that they are of deep-structured octahedrites of Sandia Mountains and Santa Luzia.

The treatment of some fragments revealed thick beams and round or polygonal formations. These structural components are closely connected or divided by grains of troilite, sometimes of considerable size, forming large inclosures. In rarer cases in contact with troilite was found *schreibersite.*

The designs on the surface of treated meteorites (see Figure 2), *a* and *b,* show certain colors depending from what angle the light strikes them; some components are very bright, others dark; also can be seen Neumann lines sometimes very distinctly. Broken-up fragments show same structure but also sharp deformations formed when meteorite fell.

Finally the following conclusions can be made: meteorite shower was

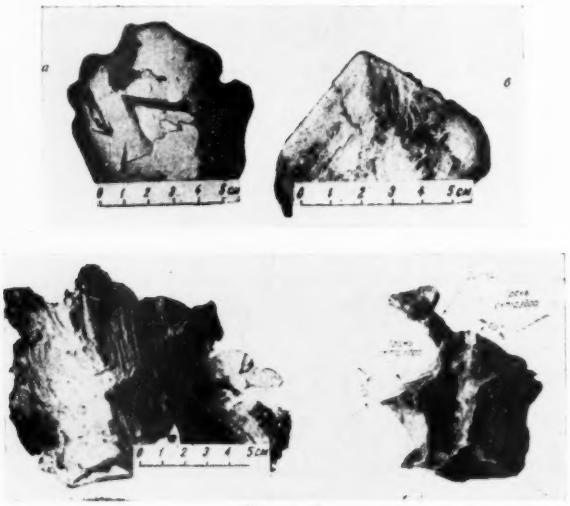

FIGURE 2

formed in the atmosphere from the one great mass. This breaking up was started from the time of entrance in the atmosphere and accomplished very close to the ground, at about a few kilometers.

Large meteorite masses on reaching the surface of the Earth with the velocity proportional to their mass broke the rocks forming craters and split themselves into small fragments. Approximately samples of 300 kg. were the largest which did not break up.

No explosion of any kind accompanied the breaking up. This is proved by the absence of any seismographic record.

Certain deformation of the surfaces of different fragments were due to high temperatures of atmospheric friction and the impact of the meteorites during the fall. Beam-grain structure helped the breaking up of the meteorites in the atmosphere and at the point of contact with the ground. In general, it can be judged, the full mass of the meteorites is about 100 tons. The expedition gathered about 5 tons of individual fragments.

The second part of these Notes has to do with a probable Leonid fireball with a long-enduring train, seen off the coast of central New Jersey on 1949 Nov. 15/16. Particularly during October large numbers of fireballs were reported but unfortunately most of them had only one observation. In the case of that on Oct. 26 at about 9:00 P.M., E.S.T., our regional director for New York, C. H. Smith, succeeded in getting about 47 usable reports and he is now finishing the solution of its path. In a few other cases two reports came in but they were too vague or inexact for heights to be computed except for one at 10:02, E.S.T., also on Oct. 26. Approximately 150 fireballs were reported during 1949 to our headquarters here, not including a few seen during regular meteor observations by our members. With all the publicity on meteors in recent years we still do not get an appreciable number of reports on any single object unless a special press

and/or radio request is made. We cannot make people understand that such reports are *always* wanted. It is particularly disheartening that most members of the various astronomical societies are, if anything, more lax in reporting than the general public.

As reported in the *Hydrographic Bulletin, U.S.N.*, on 1949 Nov. 15/16 at about 0740 G.C.T. on Nov. 16, a brilliant meteor was observed from two ships. Despite the incompleteness of the data, as a long-enduring train was left, an attempt was made to solve for the atmospheric path. This is A.M.S. No. 3549. S1. Third Officer L. L. Brown of the *Am. S. S. Bessemer Victory* reports. . . "At 0737 G.C.T., on Nov. 16, 1949, in lat. 40° 43′ N, lon. 72° 30′ W, a meteor was observed which appeared in the approximate position, R.A. 5 hours, decl. 10° N, traveled S.W. and disappeared in about R.A. 4 hours, decl. 10° S. . . . left a wake of white smoke, ziz-zag in form, which was visible for 5 minutes . . . weather . . . partly cloudy." S2. Third Officer W. G. Bennett of the *Am. S.S. Mobilgas* reports. . . "At 0742 G.C.T. in lat. 39° 20′ N, lon. 73° 58′ W. (26 miles south of Barnegat Lightship), a meteor was observed to explode directly overhead at an estimated altitude of 10,000 to 20,000 feet. The flash was white and extremely bright illuminating the sea with the intensity of a large bolt of lightning. It left a trail of smoke in a cloudless sky a couple of miles long that showed the path to be from east to west. The train persisted for about 5 minutes and was finally broken up by a gentle southwesterly wind. The smoke was visible either from hot gases or reflected moonlight from a rising last quarter moon."

The two ships have positions for which $\Delta\phi = 83'$ and $\Delta\lambda = 88' \cos \phi = 67'$. The local sidereal time for S1 is computed as 96° 48′, using the observed time of 0737. With this we computed $a_1 = 38°.2$, $h_1 = 53°.7$, $a_2 = 42°.4$, $h_2 = 29°.0$. Observer on S2 states that the object exploded in the zenith, which we infer means the end of the path as seen from S2. On a second approximation, I find the corrected altitude of the end point to be 109 km. The data from each ship were obviously very approximate, and one path would throw it considerably north of, the other south of the Leonid radiant, from which, remembering the date and the general behavior of Leonids, I have no doubt it came. However, in view of the uncertain data, a computation of the beginning height and path would be hopelessly inexact. There is even reason, from former experience, to believe that the end height is too high by probably 20 or more kilometers. According to S2 the drift of the train was towards the northeast.

One cannot refrain from again expressing the fervent wish that observers, when they see one of these rare and important phenomena, would be more careful both in giving the coordinates of the beginning and the end points of the path and also the equally important position of their ship. In this case also it seems probable that many other ships were in the vicinity but unfortunately sent in no reports.

I wish to prepare the annual report for the A.M.S. without further delay. Will all members therefore please send in any observations for 1949, still in their hands. Also the annual dues should be paid.

Flower Observatory of the University of Pennsylvania, Upper Darby, Pa.
1950 February 4.

Contributions of The Meteoritical Society
(Known Formerly as The Society for Research on Meteorites)
Edited by FREDERICK C. LEONARD
Department of Astronomy, University of California, Los Angeles 24

Intensity Variations in the Spectrum of a Perseid Meteor*

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ABSTRACT

Density measurements of the spectrum of a Perseid meteor reveal an increase in the strength of the K line of ionized calcium with respect to the neutral iron-magnesium blend at 3830 A., particularly during bursts. The greater strengthening of high-excitation lines relative to low-excitation lines during bursts appears to be fairly general thruout the spectrum. Effective-temperature determinations, based upon the relative intensities of certain iron multiplets, however, indicate lower excitation of iron vapor during bursts than between them. The effective-temperature difference is of the order of 20° to 30° C.

In the course of the Perseid shower of 1948, the spectrum of a meteor was obtained that revealed two more-or-less unusual properties. In the first place, the spectrum exhibited three well-defined phases along successive segments of the observed path. In phase one, low-excitation lines of iron appeared. In the second phase, the H and K lines of ionized calcium were easily visible, but were less intense than the neutral iron-magnesium blend at 3830 A. In the final phase, the H and K lines became the dominant features of the spectrum. A second spectrum, not yet reduced but clearly revealing the same sequence of variations, was photographed in the course of the 1949 Perseid shower. A reduction of the 1948 spectrum and a brief discussion of its different phases have already been published.[1,2] The purpose of the present paper is to consider the sequence of bursts, which constitute the second unusual property of this spectrum.

Millman finds evidence[3] of single bursts in 38 out of 98 meteor spectra that he has examined. Fifteen (15) of the 98 cases show more than one burst. A spectrum, such as the one under discussion, exhibiting 5 major bursts, tho not unique, is unusual. Such spectra are important because they may afford an opportunity to investigate changes in the relative intensities of spectral lines during and between bursts. This information, in turn, may lead to estimates of the effective temperature of the meteoric vapor and may ultimately facilitate the development of an adequate theory of the cause of bursts and the mechanism of radiation in a meteor.

Measures of photographic density were made with the aid of a visual densitometer thru which a small area of the emulsion was viewed directly in the center of the field of view. The brightness of the remainder of the field was so adjusted as to be indistinguishable from that of the emulsion. The instrument was calibrated for the direct reading of photographic density ($= \log_{10}$ opacity). As the spectral features on the original negative were too small to measure satisfactorily,

*Read at the 12th Meeting of the Society, Los Angeles, California, 1949 September 6-8.

a $\times 7$ enlargement was made on a sheet of film large enough to include the spectrum of the meteor and those of several stars.

Densities were obtained from the spectrum of the meteor for the K line of ionized calcium and for the iron-magnesium blend at 3830 A. Readings were made at each of the 5 bursts, at points between the bursts, and at 3 points preceding the bursts. The results of these measures are shown in Fig. 1. It is evident that the strength of the K line relative to that of 3830 A. increased along the path of

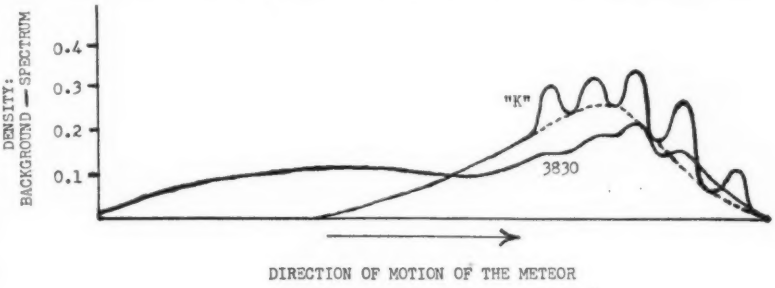

FIG. 1

DENSITY VARIATIONS ALONG THE PATH OF THE METEOR FOR THE K LINE OF IONIZED CALCIUM AND THE IRON-MAGNESIUM BLEND AT 3830 A.

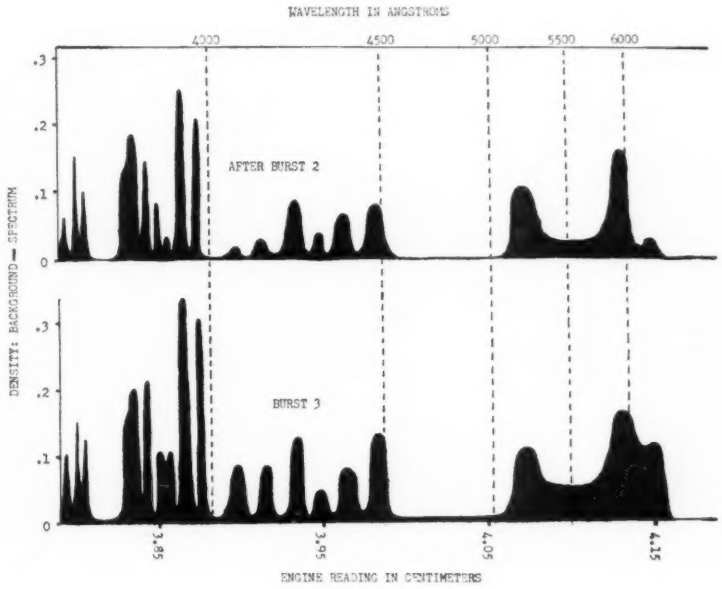

FIG. 2

CENTRAL DENSITIES OF 18 LINES OR BLENDS AFTER BURST 2 AND DURING BURST 3

the meteor. As the excitation-potentials of the upper levels involved in the production of 3830 A. are lower than the ionization-potential of calcium, the excitation of the spectrum increased with greater penetration of the atmosphere, insofar as these two lines were concerned. The excitation increased even more spectacularly during the bursts. The general increase in excitation with atmospheric penetration is frequently observed in the spectra of meteors, but the increase during bursts has not, to my knowledge, been previously noted in the literature.[4]

Two additional sequences of density measures were made parallel to the dispersion, one between the second and third bursts and one at the middle of the third burst. The results are shown in Fig. 2. The tracings are purely schematic and should *not* be considered indicative of actual line profiles. The general tendency is for the lines of higher excitation-potential to be strengthened during bursts more than the lines of lower excitation-potential. The 18 lines shown in Fig. 2 were arbitrarily classified as high, medium, or low, first on the basis of the excitation-potential of the upper level involved in the transition, and, second, on the basis of increase in density during the burst. The results are summarized in Table 1.

TABLE 1

CORRELATION BETWEEN THE EXCITATION-POTENTIAL OF SPECTRAL LINES AND THEIR DENSITY VARIATION IN AND BETWEEN BURSTS

Density Difference \ Excitation-Potential	High	Medium	Low
High	5	0	1
Medium	0	1	3
Low	0	5	3

It may be noted that all lines classified as high E.P. lines show a high increase in density during bursts. This high increase in density was exhibited by only one line of low or medium E.P. Approximately half of the lines in the low E.P. group are low in density increase; the other half show medium density increase. All but one of the medium E.P. lines ranked low on density increase. These data appear to be fairly consistent with those obtained from Fig. 1, especially for the high E.P. lines.

The meteor spectrum under discussion contains iron multiplets that were investigated by A. S. King[5] in his study of the intensities of iron lines at varying furnace temperatures. As the meteoric vapor is not in thermodynamic equilibrium, ratios of intensities of these multiplets in the spectrum of the meteor do not indicate temperature in the ordinary sense but do indicate the furnace temperature at which iron atoms at normal atmospheric pressure would be subject to a similar degree of excitation.

Millman[6] has utilized King's data to relate the effective absolute temperature of meteoric vapor and the logarithm of the total multiplet intensity ratio,

$$\frac{(41) + (42) + (43)}{(2) + (3)},$$

in which the numbers in parentheses are the iron-multiplet designations used in Dr. Charlotte E. Moore's "Multiplet Table of Astrophysical Interest, Revised Edition."[7] This relation was applied to the present spectrum in an effort to estimate the effective temperature of the vapors both during and between bursts.

Before the densities of the iron lines could be converted to intensities, char-

acteristic curves relating the degree of blackening of the emulsion to the intensity of illumination at a given wavelength had to be derived for the film on which the spectrum appeared. The spectra of β, γ, ϵ, and 50 Cassiopeiae and Polaris (α Ursae Minoris), all of which appeared on the same film as the meteor spectrum, were employed in the reduction. As the iron lines to be used fell in the wavelength range 4000-4500 A., curves were developed for wavelengths 4000, 4200, and 4500 A. These curves for individual wavelengths were found to be so similar that a mean curve was drawn, based on all three of them. In calculating the relative intensity of starlight producing the measured densities, allowance was made for the spectral class of the star, for departures from a black-body distribution of energy in the continuous background,[8] for the declination of the star, and for the angle that the dispersion made with the diurnal motion.

With the aid of this characteristic curve, relative intensities were calculated for the lines at 4061, 4216, 4284, 4362, and 4470 A. These intensities were assumed to be those of the iron multiplets (43), (3), (42), (41), and (2), respectively, to which reference has already been made. The ratio of the total multiplet intensities,

$$\frac{(41) + (42) + (43)}{(2) + (3)},$$

was formed, and its logarithm was used as the entering argument to obtain the effective temperature of the meteoric vapor from Millman's graph. The resulting temperatures are listed as T_1 in Table 2.

TABLE 2

EFFECTIVE ABSOLUTE TEMPERATURES C. OF THE METEORIC VAPOR

	Burst 1	1-2	Burst 2	2-3	Burst 3	3-4	Burst 4	Mean	Mean at Bursts	Mean between Bursts
T_1	1844°	1856°	1841°	1831°	1808°	1865°	1837°	1840°	1832°	1851°
T_2	1839°	1866°	1838°	1824°	1813°	1889°	1829°	1843°	1830°	1860°

The temperatures listed in this table are uncertain because some of the lines are blended with those of another multiplet and because some of the components of the multiplets are not included in the lines used in the ratio. As Millman found that similar curves for the logarithm of the ratio *vs.* the absolute temperature were given by individual ratios (41)/(2), (42)/(2), (43)/(2), (41)/(3), (42)/(3), (43)/(3), temperatures were read from Millman's graph with log [1½ × (43)/(3)] as the entering argument. The ratio (43)/(3) was chosen, because lines 4061 and 4470 A., whose intensities form the ratio, were believed to be essentially free from blends, and each of these lines represented about the same fraction (⅔) of the total intensity of its multiplet. The temperatures obtained from the ratio (43)/(3) appear in Table 2 as T_2.

The agreement of the temperatures T_2 and T_1 is reassuring, particularly the parallelism of increase and decrease during and between bursts. The effective temperature between bursts is apparently higher than that during bursts. Burst 2 seems to violate this generalization; it may do so because it is the longest burst and gives some evidence of being two closely spaced bursts. As the measures were made at the center of the burst, they may be a blend of burst and between-burst effects. In view of the fact that the high-excitation H and K lines are strengthened during bursts more than the low-excitation lines, the reverse effect noted for the faint iron multiplets may be open to question. Similar drops in effective temperature during bursts have, however, been previously noted by Millman[9]

in several spectra, of which at least one had more lines, better resolution, and a better characteristic curve than the spectrum here under discussion. Millman noted further, in the spectra of 4 Leonids containing no succession of bursts, that higher excitation of iron vapor accompanied greater calcium ionization. From the data described for the spectrum considered in this paper, it appears that this tendency is reversed in bursts and that the mechanism of radiation in bursts may differ in some respect from the mechanism that is normally operative. Öpik[10] has concluded, on the basis of theoretical considerations, that the radiation of a meteor arises chiefly from a coma of vapor about the incandescent meteorite, in which both temperature and impact radiation may be present. Temperature radiation is relatively more important in bright meteors of low velocity. Millman has shown that, in the exceptionally fine, type-*Z*, multiple-burst spectrum, numbered XXIV in his compilation,[9] the ratio of temperature radiation to impact radiation is greater at the bursts than during the intervals. The H and K lines, which did not appear in spectrum XXIV, complicate the picture in the case of the present spectrum by indicating a decrease in the ratio of temperature radiation to impact radiation at the bursts. It is tempting to hypothesize that the observed spectrum is an integration of light from at least two regions in the source, in which the physical conditions differ from each other. Probably the wiser procedure would be to concentrate on seeking further observational verification of this behavior, in view of the rather high systematic and accidental errors to which measures of under-exposed, low-dispersion meteor spectra are subject.

I wish to express my sincere thanks to Dr. Peter M. Millman, of the Dominion Observatory, Ottawa, Ontario, Canada, for his helpful criticism of this paper and for data generously supplied in advance of their publication.

References and Note

[1] Russell, John A., *C. M. S.*, **4**, 191-6; *P. A.*, **57**, 187-92, 1949.
[2] Russell, John A., *C. M. S.*, **4**, 204-5; *P. A.*, **57**, 344-5, 1949.
[3] Millman, Peter M., unpublished at the date of this writing.
[4] Millman states in private correspondence: "The same phenomenon is present in spectrum LVIII, *Jour. Roy Astron. Soc. Canada*, **34**, Plate XXV, 1940, [of] a Perseid meteor, mag. —3, observed at Ottawa, Aug. 11, $3^h\,47^m$ EST, 1940. A detailed study of this spectrum has not yet been published. . . ."
[5] King, Arthur S., *Astroph. Jour.*, **37**, 239, 1913.
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[7] Moore, Charlotte E., *Princeton Univ. Obs. Contr.*, No. 20, 1945.
[8] Stebbins, Joel, and Whitford, A. E., *Astroph. Jour.*, **102**, 318, 1945.
[9] Millman, Peter M., *Harvard Coll. Obs. Ann.*, **82**, No. 7, 149-77, 1935.
[10] Öpik, E., *Tartu Univ. Publ.*, A XXVI. 2, 1933.

Erratum in the December, 1949, Issue.—In *C. M. S.*, *P. A.*, **57**, No. 10, Dec., 1949, 7th line from the top of p. 510, in the paper by Barringer and Hart, "longer than 10 cm., 10^{-10}" should read "longer than 10 cm., 10^{-14}."

President of the Society: Arthur S. King, 925 Topeka Street, Pasadena 6, California

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VARIABLE STARS

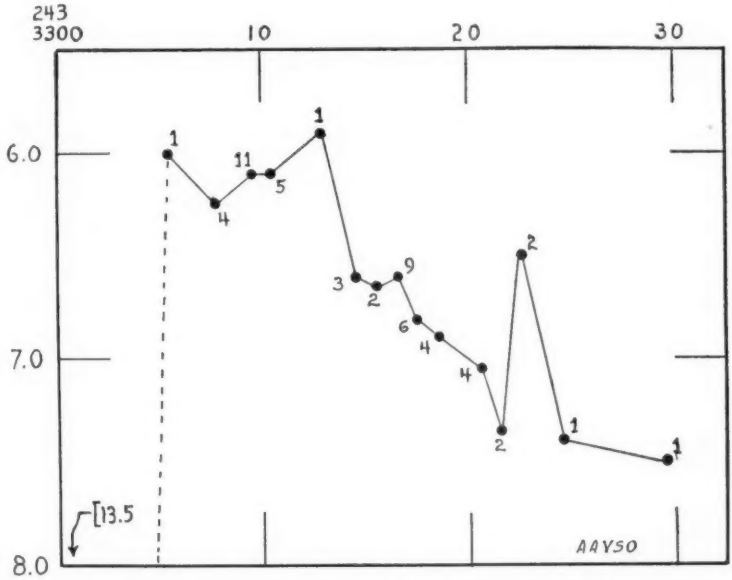
Variable Star Notes from the American Association of Variable Star Observers

By MARGARET W. MAYALL, Recorder

Nova Lacertae 1950, $22^h\,48^m0$, $+53°\,02'$ (1950). The Nova Search Program was activated in the latter part of January by the discovery of a nova in Lacerta, of sixth magnitude—just on the border line of naked-eye visibility. It was discovered on January 23 by Ch. Bertaud, in Meudon, France. The first observations in the United States were made on January 25, by three AAVSO members in Washington, D. C.: Morgan Cilley, Miles Davis, and John Lankford. Photoelectric measures were also made the same night at the U. S. Naval Observatory by A. H. Mikesell and J. S. Hall.

Miss Hoffleit has searched the Harvard photographs and finds a star of magnitude 16.3 on many early plates, at or near the position of the nova. It is impossible to determine whether the object is the nova at normal brightness, before the explosion, or whether the nova was fainter than the plate limit. Mr. Balfour S. Whitney, of the University of Oklahoma, writes that on three plates taken on the night of January 18, the nova was not seen and must have been fainter than 13.5.

Our observers have been very enthusiastic about watching the nova, and in spite of heavy clouds across the country most of the time, we have received



MEAN LIGHT CURVE IN 1950 OF NOVA LACERTAE 224552.

observations made on fourteen nights out of the 23 since the announcement of the discovery.

The nova seems to be one of slow type, for it has faded only one and one-half magnitudes in more than 3 weeks. It should be followed closely to watch for any sudden changes. The accompanying mean light curve shows the observations received up to February 17. The number beside each point is the number of observations included in the mean.

SS Cyg, 213843. SS Cygni started a rapid rise to maximum on J.D. 2,433,298. Ten days later it was still brighter than ninth magnitude.

—Cet, 013418. (The "flare star.") A number of observations have been made of this star, but so far no AAVSO observer has found it bright.

U Ori, 054920a. At the last minimum of U Orionis, the observations showed much more scattering than usual, amounting to nearly 3 magnitudes, during the hundred days around minimum.

SS Aur, 060547. A maximum was observed at about J.D. 2,433,280.

S Aps, 145971. S Apodis is slowly climbing back to maximum. It was 10.8 magnitude the last of December.

R CrB, 154428. R Coronae has now increased to about magnitude 6.5, J.D. 2,433,000.

RU Peg, 220912. A maximum was observed at about J.D. 2,433,270.

According to a letter I recently received from Mr. Sakuma Seiichi, the Secretary of the Variable Star Section of the Japanese Astronomical Research Society, the Japanese amateurs have been very busy observing variables since 1945. His outline of the number of their observations follows:

1945: 4,500 estimates by 31 observers
1946: 15,682 estimates by 40 observers
1947: 9,335 estimates by 38 observers
1948: 6,301 estimates by 31 observers.

The official report of this excellent work will be printed in the *Publications of the Astronomical Society of Japan.* Mr. Seiichi says one of their greatest troubles is their lack of contact with work being done overseas.

Personal. All members and friends of the AAVSO will be delighted to hear that one of our active members, William Grant Tifft, has been named as one of the 40 Science Talent Search Winners of 1950. He is the only finalist from the state of Connecticut. The subject of his essay was on introductory astrophysical studies. He is the second AAVSO member to achieve this distinction, for Carl Werntz of Washington, D. C., was one of the 40 winners in 1949.

Observations received during January. A total of 3,504 estimates was received during the month from 55 observers, as follows:

Observer	No. Var.	No. Ests.	Observer	No. Var.	No. Ests.
Adams	36	61	Charles	19	20
Ahnert	26	64	Cilley	27	51
Ancarani	21	22	Cragg	138	138
Armfield, E.	1	7	Darling	13	21
Armfield, L.	4	43	Davis	1	2
Azok	1	1	Diedrich, DeL.	2	7
Bogard	48	106	Diedrich, G.	2	9
Burkhead	1	2	Dillon	5	8
Cain	3	3	Drakakis	18	60
Chandra	42	46	Escalante	152	234

Observer	No. Var.	No. Ests.	Observer	No. Var.	No. Ests.
Estremadoyro, V. A.	6	8	Oravec	57	160
Fernald	326	674	Pearcy	46	49
Ford	10	10	Peltier	177	210
Galbraith	17	97	Penhallow	39	70
Greenley	64	113	Pierson	23	23
Hartmann	156	161	Renner	111	111
Herring	3	3	Rick	1	2
Hiett	13	13	Rosebrugh	19	63
Holloway	5	6	Sill	25	30
Knowles	3	3	Stevens	15	20
de Kock	110	402	Taboada	85	108
Lacchini	60	70	Tifft	1	1
Lankford	12	30	Upton	3	3
LeVaux	27	28	Venter	17	31
Lowder	19	20	Waters	2	2
Luft	6	20	Yamada	19	46
Mason	3	4			
Mayall	1	1	55	(Totals)	3504
Meyer	3	7			

Nova Search: Reports on the Nova Search Program were received from 5 observers on areas as follows:

Adams: 16, 17, 33, 34.

Luft: 25, 26, 27, 33, 34, 35.

Rosebrugh: Dome, 1, 34.

Smith, F. W.: 3, 4.

Yamada: 19.

February 17, 1950.

Comet Notes

By DANIEL L. HARRIS III

The 1950 edition of "The Handbook of the British Astronomical Association" supplies the following information in regard to expected returns of periodic comets in 1950.

Comet Väisälä (1), 1939 IV was recovered by Mrkos on 19 December 1949, the perihelion passage having occurred on 11.4 November 1949. It will remain of about the 17th magnitude.

Comet Reinmuth (1), 1928 I was recovered by Mrkos on 19 November 1949, though perihelion passage will not occur until 22 July 1950. It will remain between the 17th and 18th magnitude.

Comet d'Arrest, which was discovered in 1851 and has been seen at nine returns, is the only periodic comet which will be bright enough for medium-sized telescopes. It is of special interest because it appears to have a disturbed period. The predicted positions for March and April are given below.

Date		α h m	δ ° ′	Mag.
March	10	19 22.4	— 8 03	14.4
	20	19 52.0	7 09	
	30	20 22.5	6 03	13.7

Date		α h m	δ ° ′	Mag.
April	9	20 53.9	4 47	
	19	21 26.1	3 23	13.0
	29	21 58.9	1 57	
May	9	22 32.2	— 0 30	12.5

Comet Daniel will come to perihelion on 24 August 1950, but will be fainter than the 15th magnitude.

Comet Wolf (1) will come to perihelion on 23 October 1950, but will be very faint.

Comet Oterma, 1942 VII, and Comet Schwassmann-Wachmann (1), 1925 II, are visible every year, but both are generally too faint to observe with small telescopes. However, the latter comet is known to brighten about five magnitudes in the course of a few days, without any apparent cause. The predicted positions for March and April are given below.

Date	α h m	δ ° ′
March 10	10 05.5	+ 9 33
20	10 01.9	9 48
30	9 58.9	10 01
April 9	9 56.7	10 10
19	9 55.3	10 15
29	9 54.8	10 16
May 9	9 55.2	+10 12

It should be emphasized that the comet will probably be between the 16th and 17th magnitude, but it is impossible to predict when it will flare up.

Warner and Swasey Observatory, East Cleveland 12, Ohio.

Communications and Comments

Under this heading we shall publish from time to time such material as does not properly fall under any of the established headings of this journal. Here, too, may be found, when occasion arises, articles which the editor may not be willing to give sanction to but which, nevertheless, may be provocative of thought along new lines.

Imaginary Conversations

Time—Circa 150 A.D.

Place—Realm of Pluto

Pluto—I have summoned you, illustrious Shades, to greet a new arrival. On earth he achieved fame second to none of you. His name is Ptolemy, and his home was Egypt. In his honor I have granted you the privilege of coming to this Conclave.

Chorus of Shades—Hail, Ptolemy!

Pluto—Three hundred years have lapsed since I allowed you to foregather, but you failed at that Conclave so distressingly to agree on the nature of the Cosmos I have felt it useless to summon you again. However, when I learned that the distinguished astronomer was on the way to my kingdom, I decided to give you another opportunity. No doubt he can add very important information.

THALES—Ptolemy, we can't honestly welcome you to this region of shadows, but if you really can throw any light on the vexing problems we were unable to solve, we will certainly welcome that.

PTOLEMY—Much has happened on earth in the past three hundred years, so I should be able to afford you a measure of satisfaction. However, I wish to know whom in this land of Shades I have the honor of addressing.

THALES—Well spoken, Ptolemy; I am Thales of Miletus. This is Anaximander, my disciple and successor, and this is Anaximines, who carried on his work. Here is Ionian Anaxagoras, and next to him Pythagoras of Samos, and on his right Philolaus of Crotona, a devoted pupil. Yonder is Heraclides of Pontus, and besides him Athenian Meton. To his left in order Eudoxus of Cnidus, Hipparchus of Nicaea, Apollonius of Perga, Aristarchus of Samos, and Eratosthenes of Cyrene.

PTOLEMY—Illustrious Shades, your names to me on earth were household words. To several of you I was greatly indebted, and although I disagreed with some of you, I count it an honor that all are here to greet me.

THALES—Tell me, Ptolemy, if the living who are privileged to study the heavenly bodies are certain that the moon gets its light from the sun, and that at conjunction it becomes invisible because hidden in the sun's glare?

PTOLEMY—Yes, Thales, astronomers are certain that the moon shines by light reflected from the sun: but the moon can not be hidden in the glare of sunlight.

ANAXIMANDER—Do they believe that the earth is more or less flat, or is a sphere at the center of the Cosmos?

PTOLEMY—Most put the earth at the center of the universe and believe that it is a sphere in free space, hence not anchored like a mountain to the ground beneath.

PYTHAGORAS—Your second statement is correct, but your first, ridiculous. I think the sun is the center around which the spherical earth revolves in 365 days and a fraction. The planets also are spheres revolving around the sun, otherwise how can you explain the identity of the evening and morning stars, first by me pointed out? The earth has to be spherical since the shadow it casts on the surface of the moon at eclipse always is curved.

HERACLIDES—You are partly right and partly wrong, Pythagoras. I agree that the earth is a sphere revolving around the sun; but you don't go far enough. I believe the earth turns on an axis daily from west to east, and that this diurnal motion is what causes the stars at night to move from east to west.

ANAXIMANDER—Absurd, Heraclides. If the earth is a sphere turning daily on an axis, why don't we fall off into space every twelve hours when we are upside down? Common sense should teach you that.

PHILOLAUS—I can answer for Heraclides. The reason why we don't fall off into space when in what you call the upside down position is due to some strange provision of Nature that causes all heavy objects to cling to the earth. Even a leaf if not carried by the wind will fall to the ground and stay there.

ANAXIMANDER—Mere surmise, Philolaus. Believe it if you wish, but I prefer to abide by common sense logic.

ANAXAGORAS—I am inclined to agree with Philolaus and Heraclides. I worked out the reasons for the moon eclipses, and noted the curving of the shadow on the moon's surface. That shadow proves definitely that the surface of the earth is curved, therefore that the earth is a sphere. If so, there is no reason why it shouldn't rotate on an axis: but since I believe the earth to be at the center of

the universe I hold that the sun and other heavenly luminaries must necessarily travel around it.

APOLLONIUS—You are inconsistent, Anaxagoras. You admit the earth is a rotating sphere at the center of the Cosmos. If, as you say, the sun, moon, and planets revolve about it, I suppose you assume that the stars do also. Have you ever tried to figure out how rapidly the crystalline sphere that carries the stars would have to revolve in order to complete its diurnal journey? The velocity would be unbelievable, perhaps physically impossible.

ANAXAGORAS—With the blessed gods all things are possible. Common sense indicates that our earth is at the center of things, so I hold that the stars travel around it.

PYTHAGORAS—Of course I disagree, Anaxagoras, but it's useless to argue with one who quotes common sense as a guide in scientific matters. I should like to know, Ptolemy, if you can report on my expressed conviction that number is all-important; in fact, is basic to ultimate reality. You remember that I held ten to be the perfect number, so asserted that the luminaries must be ten in number. However, as observation revealed only nine, I assumed an invisible tenth luminary—a counter-earth closely associated with our sphere.

EUDOXUS—I can tell you, Pythagoras, that your counter-earth hypothesis was discredited even before my death. It was but a wild guess on your part. May I ask, Ptolemy, if the estimate I arrived at about the relative lengths of the diameters of the sun and moon was ever confirmed?

PTOLEMY—If my memory does not trick me, you held that the diameter of the sun was nine times longer than that of the moon. While astronomers are not yet able to determine these relative diameters with perfect accuracy, they are quite certain your estimate was entirely too small; in other words that the sun is immensely larger than the moon.

EUDOXUS—I take for granted you recall that I was the first astronomer to explain mechanically the apparent motions of the planets. In order to account for their retrograde and forward motions I assigned to each planet three or more spheres revolving intricately about each other. I wasn't altogether satisfied with the hypothesis, still I should like to know what astronomers thought of it.

PTOLEMY—Your followers found the mechanical hypothesis unworkable. So many inequalities and new movements were discovered, each calling for the addition of a sphere, the complications finally became unintelligible.

PYTHAGORAS—Disappointment seems to be our fate; nonetheless I am curious to know if my hypothesis about the music of the spheres fared any better than my counter-earth idea. I based that hypothesis on the belief that as the crystalline spheres with their attached luminaries rolled ceaselessly round each other they emitted sounds, far too subtle for human ears to detect. These musical sounds were proportional to the respective distances of the luminaries from the earth, and were based on a harmonic law I had discovered.

PTOLEMY—You and your celebrated School in Southern Italy rendered to the cause of science many great services, but frankly I must report that your doctrine of number and your thesis about the music of the spheres were outmoded long before my birth.

ERATOSTHENES—I am very eager, Ptolemy, to know whether my attempt to determine the size of the earth by measuring the distance between Alexandria and Syene, and by determining the amplitude of the celestial arc between the zeniths of the two cities gave an approximately correct answer.

PTOLEMY—Your very ingenious experiment was mathematically correct, and

if the base line measurements connecting Alexandria and Syene had been exact, your trigonometrical conclusions would have been final. Your experiment elicited universal applause.

ERATOSTHENES—This is indeed most gratifying. Further, please tell me if my investigations culminating in the discovery of the obliquity of the ecliptic were later confirmed.

HIPPARCHUS—I can answer for Ptolemy by assuring you they were unquestionably confirmed by my experiments at Rhodes, and I am sure Ptolemy will back me up.

PTOLEMY—It affords me pleasure, Eratosthenes, to report that several other astronomers have confirmed your work on the obliquity of the ecliptic.

HIPPARCHUS—May I inquire, Ptolemy, if my conclusions relative to the eccentricity of the sun's orbit have been approved?

PTOLEMY—Yes, astronomers seem quite certain that the distance of the sun from the earth varies at different times of the year; so it appears that the earth is not at the exact center of the solar orbit, otherwise there would be no observed inequality of solar motion.

PYTHAGORAS—Your discussion regarding the eccentricity of the solar orbit is of profound interest. Why can not this eccentricity be accounted for by assuming with all Pythagoreans that the sun, not the earth, is the center of motion. If you hold that the earth is not at the exact center around which sun, moon, and planets revolve, why may I not hold that the sun is not at the exact center around which the earth, the moon, and planets revolve?

ARISTARCHUS—Inasmuch as I spent many years in an effort to determine the magnitude and distances of sun and moon I feel competent to say that so far as eccentricity mathematics may be applied, either hypothesis can be justified. The issue can not be settled until astronomers establish factually whether the sun moves about the earth as approximate center, or the earth revolves about the sun.

CHORUS OF SHADES—You are right, Aristarchus, and who is better qualified than Ptolemy to settle this issue.

PTOLEMY—You flatter me by assuming that I can settle the issue. Naturally I have devoted much thought to the workability of the heliocentric theory. However, since philosophers generally agree that any attempt to explain phenomena should make use of the simplest hypothesis available that will coordinate observable data, and since I had to make choice in order to perfect my system, I thought the wiser course would be to follow the lead of the majority of my predecessors, therefore backed the geocentric hypothesis.

PARTIAL CHORUS OF SHADES—You showed good judgment, Ptolemy.

ARISTARCHUS—Respectfully I dissent, for while alive I observed that the majority frequently was wrong. However, I subside, and ask merely that you outline the system alluded to in order that we may judge its merits. As you have had the benefit of our failures, you ought to be in position to register many signal advances.

PTOLEMY—First of all I must express my indebtedness to Eudoxus and Hipparchus. Your thesis, Eudoxus, designed to explain the apparent motions of sun, moon, and planets by assuming they were carried round in crystal spheres concentric with the earth, when amplified by Hipparchus, enabled me to perfect my geocentric system employing epicycles and deferents.

CHORUS OF SHADES—These are strange terms; please explain them.

PTOLEMY—My hypothesis assumes that each of these luminaries is carried round the earth in an epicyclic orbit while the immensely larger orbit called

deferent carries the epicycle with it around the earth. To make this clear, imagine a very large circle to represent the orbit of sun, moon or planet. This is called a deferent. Next imagine a small circle superimposed on this deferent, and called an epicycle. The planet moves round the epicycle and the epicycle around the deferent. This dual motion readily accounts for the retrograde as well as the forward motion of the planets. By means of tables based on many observations I was able to predict the positions of sun, moon, and planets at any future time.

ARISTARCHUS—Were your predictions always exactly verified by observation?

PTOLEMY—Honesty compels me to reply in the negative. Occasionally I had to add an epicycle to epicycle.

ARISTARCHUS—Could not all those complications have been avoided by taking the sun as center around which the earth, the moon, and the planets revolved? That would prevent superimposing epicycle on epicycle.

PTOLEMY—I can not answer this inasmuch as all my data were based on geocentric observations.

HIPPARCHUS—I think your objections, Aristarchus, are quibbles. Since the epicyclic hypothesis readily accounts for all phenomena, why should Ptolemy waste time on an unproved hypothesis?

ARISTARCHUS—I am no quibbler, Hipparchus. Isn't it necessarily true that, if in order to equate observation with tabular data even one epicycle must be superimposed, the hypothesis is defective, hence the earth can not be the approximate center of movement? Complications will keep in step with observations. Epicycle after epicycle will have to be added until finally the hypothesis will crash under its own weight. You were a geometer, so know that if the baseline is incorrectly measured, triangulation errors increase at every step.

HIPPARCHUS—Your logic is beyond question, I must admit, so we shall have to let time settle this disputed point. May I ask, Ptolemy, if your calculations were based on the division of the circle into 360° after the Babylonian method? I was first among the Greeks to adopt this division.

PTOLEMY—Yes, all mathematicians have used this system since you introduced it to the Greek world. Further, you may be interested to learn that your calculations fixing the precession of the equinoxes at 36 seconds of arc annually have proved too small by ten or twelve seconds. The exact size of the earth is not yet known, so I can not affirm or deny your conclusion that the diameter of the moon is one-third that of the earth, and that its distance from the earth is 33 and ⅔ times the earth's diameter.

METON—You have no doubt noticed, Ptolemy, that I have kept silent while my illustrious fellow Shades have kept you busy answering questions. Indulge me for a moment, please, by telling me if the Metonic Cycle that I worked out has stood the test of time?

PTOLEMY—It is a genuine pleasure, Meton, to report that your Cycle has received universal acclaim, although it has had to be slightly modified at times to match somewhat more accurate observations. Recent instruments are more refined than those you used.

PLUTO—It appears to me that you illustrious Shades are still far from unanimous agreement about the nature of the Cosmos, so it may be necessary for me to wait the lapse of additional centuries before summoning you to another Conclave. Unhappily the Olympian Gods have kept me as ignorant as you about these celestial problems. You may now return to your respective circles.

LABAN LACY RICE.

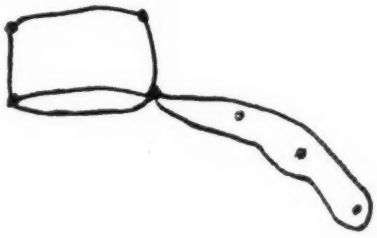
Ware Neck, Virginia.

How Paul Bunyan Departed the Earth

Paul Bunyan, the giant axeman of the northern woods, had been longing for years to have a coonskin cap—not just any coon skin cap, but one befitting his already legendary stature as well as his head.

Paul, who stood a thousand axe handles high, had hunted coons all over the face of the earth, but nowhere had he found an animal big enough to satisfy him.

At long last, Paul (who left footsteps all over Minnesota and Michigan which filled up and became lakes) decided he had found the cap he wanted hanging in the northern sky. It looked like this:



Paul watched this coonskin cap circling around the North Star until he thought that he had correctly estimated its velocity and then he leaped for it.

He had, however, miscalculated and jumped a little too early; also he was thrown southward by the rotational velocity of the earth, so we see him today—caught upon the celestial sphere—still trying to get his coonskin cap.

The Greeks, of course, miscalled him Orion (having no means of knowing about Paul) and gave the name of dog to his blue ox, Babe, who jumped into celestial immortality with him.

HECTOR F. MCLEAN.
Member of class in General Astronomy, Univ. of Cal., Berkeley.
January, 1949.

Mr. Chapman Grant raises some Questions

Dr. J. Hugh Pruett on page 39 of the January issue of this journal clears up the use of the terms "meteor" and "meteorite," but at the same time he makes a statement which brings two other terms forward which are still more in need of being cleared up.

Dr. Pruett says: "The small 'shooting stars,' which *burn* completely to *ash* high in the air . . ."

To the layman and the dictionary, "to burn" is to undergo combustion. Combustion in turn is any chemical process accompanied by the evolution of light and heat.

We read that the meteorites causing "shooting stars" are the size of grains of sand or grains of wheat. That the friction resulting from penetration of our atmosphere which they enter at a rate of 24 miles per second, raises their temperature to incandescence. The accompanying light is the meteor.

Is not this erosion of their surfaces actually *ablation?* Is there a chemical process involved or is it purely physical, without molecular change? If chemical, what gas does iron or nickel form? To what temperature are these tiny grains raised? What temperature would be required in the higher atmosphere to turn

these metals into gas? Could there actually be either burning or combusion?

It has always appeared to me that such a small grain would be almost immediately slowed down by two factors. First the increasing density of the air as the earth is approached and second, the progressive loss of mass of the rapidly eroding grain. Why then do not the "shooting stars" travel more slowly before disappearing? Some of them describe a considerable arc, but appear to travel at a fixed rate.

"Ash" to the layman and the dictionary is the solid residue left when combustible material is thoroughly burned at not too high a temperature.

We were told that these "shooting stars" were "completely burned to ash." We cannot understand how a complete burning would leave any ash, or what elements in the grains are turned to gas and which to ash. We particularly wish to know what becomes of the ashes. Are any recovered in ocean ooze? Could there, in fact, be any ashes at all?

2970 Sixth Ave., San Diego 3, California.

General Notes

Dr. Otto Struve, Chairman of the Department of Astronomy, University of Chicago, has accepted a Professorship in astrophysics on the Berkeley campus of the University of California, effective July 1, 1950. He will assume the chairmanship of the Department of Astronomy at California replacing Professor Sturla Einarsson who retires June 30, 1950.

Dr. Struve who was the former Director of the Yerkes Observatory, University of Chicago, and of the McDonald Observatory jointly operated by the University of Chicago and Texas, will retain a connection with the University of Chicago as Research Associate and will continue some observational work at the McDonald Observatory.

The department of astronomy at the University of California was made famous by Professor A. O. Leuschner and was later ably conducted by Dr. R. T. Crawford as well as by the present chairman, Dr. S. Einarsson.

Dr. Struve has been connected with the Yerkes Observatory and the University of Chicago for more than twenty-eight years, during which, largely due to his energy and enthusiasm, the Yerkes Observatory has had a phenomenal development.

The Rittenhouse Astronomical Society of Philadelphia held its monthly meeting on February 17, 1950. The speaker on this occasion was Dr. Harlow Shapley, director of Harvard College Observatory.

The Flower Observatory of the University of Pennsylvania has loaned its astrographic mounting and three cameras, a 10¼, a 5, and a 4-inch, to the McDonald Observatory for a period of five years. This equipment will be used in Texas to finish the great Milky Way Atlas, which, because of latitude and poor seeing, could not be done in Philadelphia.

Amateur Astronomers in California

David Barcroft, Madera, California, chairman of the Convention Committee of Western Conference of Amateur Astronomers, has announced that the 1950

Convention will be held at Palo Alto, California, on August 14, 15, and 16. Further inquiry may be directed to Mr. H. A. Wallace, 2925 A, Jackson St., San Francisco 15, California.

Provisional Sunspot Numbers for January, 1950*

1	101	11	70	21	155
2	100	12	67	22	163
3	92	13	65	23	146
4	84	14	71	24	157
5	76	15	70	25	136
6	85	16	65	26	124
7	84	17	78	27	108
8	86	18	92	28	109
9	64	19	107	29	98
10	83	20	130	30	118
				31	80

Mean Value for January
R = 98.8

*From the Zürich Observatory, furnished by Mr. Neal J. Heines.

Dome Being Built for New Lick Observatory Telescope

Construction has been begun on the dome for the new 120-inch telescope at the University of California's Lick Observatory at Mount Hamilton.

The building will be constructed by Carrico and Gautier, of San Francisco, who have been awarded a $638,800 contract by the Regents of the University. Completion is scheduled for May, 1951.

The structure will be located on a ridge about one-third of a mile northeast of the present main building. The building will be 96 feet in diameter and the top will be 97 feet above ground level. Two stories of miscellaneous quarters will be a part of the building. These will include offices, an optical laboratory, machine and electronics shops, darkrooms, a visitors' lounge and a visitors' gallery where visitors may view the instrument. A unique feature will be four bedrooms in which astronomers working long hours late at night can nap.

A working gallery for astronomers will be above the second floor, around the inside of the dome. The dome itself will be spring-mounted, riding on steel wheels rolling on a heavy steel rail. Thirty truck assemblies will support the dome.

Upon completion, the building will be fitted temporarily as an optical shop for grinding and testing the 120-inch mirror and the smaller auxiliary mirrors. Grinding of the mirror and construction of the mounting for the telescope will be undertaken simultaneously. Completion of both is scheduled for the summer of 1953.

From University of California Clip Sheet, Jan. 24, 1950.

Astronomical League Convention Program
Wellesley, Massachusetts—July 1-4, 1950

The Astronomical League announces that the 1950 convention will be held at Wellesley College, Wellesley, Massachusetts, July 1-4. The program begins with an informal open house at Harvard Observatory in Cambridge at 3 P.M. on Saturday, July 1.

The convention sessions will include observational work for amateurs; variable and double stars; solar, aurora, occultation and meteor observing; lunar and planetary observing and an instruments section.

Dr. William A. Calder, Agnes Scott College, Decatur, Georgia, will be speaker at the convention banquet on Monday evening. On Tuesday, July 4, a field trip will be made to Harvard's Oak Ridge Station and to the new Boston Museum of Science where there is a Spitz Planetarium. Another highlight of the convention will be the "Panel of Experts" expected to include several well known Harvard astronomers. There will also be an exhibit of photographs, charts, diagrams, instruments and accessories.

The Whitin Observatory at Wellesley will be open from 9 until midnight on July 1, 2, and 3 and an Outdoor School for Observers will be held. This is expected to include demonstrated instructions on how to observe the sun, variable stars, double stars (with the Whitin Observatory 6-inch telescope equipped with a position micrometer), planets, nebulae and clusters, and the moon.

Accommodations will be provided in Tower Court at Wellesley College. These include three nights lodging beginning Saturday evening, July 1, and ending Tuesday morning, July 4, three meals Sunday, three meals Monday and breakfast Tuesday. The basic charge for this is $15 per person plus $1 for the convention registration fee, provided that a 5 dollar deposit is placed and registration is made before April 1. Checks and money orders should be made payable to the Bond Astronomical Club. Registrations made subsequent to April 1 will be slightly higher in cost. Reservations will be accepted until the Wellesley College accommodations are filled to capacity, and those received thereafter will be returned.

Swimming will be permitted in Lake Waban and a special charge of one dollar per person for swimming privileges covers the entire period of the convention.

All signs point to the Wellesley convention as being one of the best in Astronomical League history. We wish to urge all amateur and professional astronomers to give early consideration to attending and taking part in the varied program.

CHARLES A. FEDERER, JR.
Chairman, Wellesley Convention, Harvard College Observatory, Cambridge 38, Massachusetts.

Notes from the Yerkes Observatory

(July to December, 1949)

The Observatory has continued to benefit from visits by prominent astronomers and physicists, many of them from abroad. During July and August, Professor Rupert Wildt from Yale University worked at Yerkes on his formulation of the equations of radiative transfer in terms of entropy, and Dr. J. T. Kent from Texas A. & M. lent his efforts to the astrometric program. Dr. ter Haar from Purdue University was appointed Visiting Professor for the Summer Quarter, and presented an interesting series of lectures entitled "Problems in Cosmogony," ranging from a modification of the Weizsäcker hypothesis of the origin of the solar system to a possible explanation of the varying rotations of the early type stars.

Other visitors included, in August, Professor C. G. Gorter from Leiden, who spoke on the production of very low temperatures in the laboratory; in Septem-

ber, Professor D. Shoenberg, from Cambridge University, another low-temperature physicist, and Professor W. H. Zachariasen, Chairman of the Physics Department in the University of Chicago, who spoke on the crystal structure of the trans-uranium elements; in October, Professor R. J. Siegert of Northwestern University, who spoke on statistical equilibrium; and, in November, Professor J. Neyman from the University of California, who spoke on probability theory, and C. F. von Weizsäcker of Göttingen, now visiting professor at the University of Chicago, who spoke on turbulence in the extragalactic nebulae. From France we had Mlle. R. Canavaggia and Dr. V. Kourganoff of the Paris Observatory who brought with them Dr. Chalonge's remarkable ultraviolet spectrograph and spent several months at the McDonald Observatory photographing the spectra of early-type stars. They later visited Yerkes for several more weeks. From Italy we had Dr. M. G. Fracastoro of Florence, Dr. E. C. Krüger of Merate, Dr. M. Cimino of Rome, and Professor A. Colacevich, new Director of the Naples Observatory, who later spent one month observing at the McDonald Observatory with the photoelectric photometer on the 13-inch reflector.

In August Dr. L. Binnendyk of the Sproul Observatory spent several weeks at Yerkes studying the Morgan system of spectral classification, and Dr. A. B. Meinel, National Research Council Fellow from the Lick Observatory, arrived in late November to study night sky spectra with his new and powerful grating spectrograph.

In early December Professor K. O. Kiepenheuer arrived from Freiburg, Germany, for a year's appointment as Research Associate to study the solar atmosphere as part of an ONR contract, possibly using Hale's original spectroheliograph attached to the 40-inch telescope. Dr. Su Shu Huang was appointed Instructor and Dr. Nancy Roman, Research Assistant, for one year, from 1 September 1949. Dr. Leonide Rosino, from Boulogna, Italy, arrived in late November to take a position as Research Assistant.

Dr. A. Brown, Commonwealth Fellow from Edinburgh, continued his work on globular clusters, and spent two months observing at McDonald. Mr. Donald Osterbrock started work in theoretical astrophysics on an Atomic Energy Commission Fellowship, 1 October 1949. The following are serving as Assistants through the year: Frank Edmonds, Henry Horak, Jane Ramsey, and Bruce Stephenson.

Seven students have completed work at the Yerkes Observatory for the Ph.D. degree during the past year as follows:

Su Shu Huang (June): The Continuous Absorption of Helium.

Daniel L. Harris III (June): The Satellites of Uranus.

Arne Slettebak (June): The Rotation of O- and B-type Stars.

Nancy G. Roman (June): The Ursa Major Group.

Marshall Wrubel (June): Problems in Radiative Transfer.

Arthur D. Code (November): Radiative Equilibrium with Both Pure Scattering and Pure Absorption.

K. N. Rao (November): The Structure of the CO Molecule.

Dr. Huang has been appointed Instructor, as noted above. Dr. Harris has taken a position at the Warner and Swasey Observatory, Cleveland; Dr. Slettebak is at the Perkins Observatory, Delaware, Ohio; Dr. Roman has been appointed Research Assistant as noted above; Dr. Wrubel has a National Research Council Fellowship at Princeton; Dr. Code has taken a position at the Leander McCormick Observatory, Virginia; and Dr. Rao has returned to India.

Members of the Observatory staff have contributed numerous papers to sci-

entific journals during the year, and, during the Autumn Quarter, offered the following courses for the eleven graduate students at the Observatory:

O. Struve, Elementary Spectroscopy.

G. Münch, Stellar Atmospheres.

W. P. Bidelman, Atomic Spectra.

The more exciting, extracurricular activities of the staff range from Professor (emeritus) Van Biesbroeck's half-year trip to Belgium and the Belgian Congo to investigate locations for a Scientific Research Institute and Astronomical Observatory in Central Africa, to cooperation in the publication of a new book, "Topics in Astrophysics," edited by Dr. Alan Hynek of Ohio State, which will represent the work of Yerkes staff members, past and present, past Yerkes students, and visiting astronomers.

Professor Hiltner has installed the 13-inch Cassegrain reflector on a new mount at McDonald and equipped it for general photoelectric photometry.

Professor Kuiper has been elected a fellow of the American Academy of Arts and Sciences. On 10 October he gave the College Physical Sciences Lecture in Chicago "On the Origin of the Solar System," in which several new and important changes in the Weizsäcker theory were proposed. Professor von Weizsäcker was present at this lecture, and an interesting and fruitful discussion ensued.

Professor Chandrasekhar gave the third Henry Norris Russell Lecture before the American Astronomical Society at Ottawa, in June, on "Turbulence," a hydrodynamical concept of growing importance in astronomy.

Professor Struve left on an extended trip through western Europe in early September, attended the meeting of the Astronomische Gesellschaft at Bonn, Germany, received the degree of Sc.D. from the University of Liege, Belgium, visited the observatories of Leiden, Paris, Oxford, Cambridge, Herstmonceaux, and Edinburgh, and gave the George Darwin lecture before the Royal Astronomical Society on "Spectroscopic Binaries."

THORNTON PAGE.

Book Review

Mappa Coelestis Nova, by V. Neubert, printed in Czechoslovakia. (Distributed by Sky Publishing Corporation, Harvard College Observatory, Cambridge 38, Massachusetts.)

This new map of the heavens is, indeed, true to its name. It includes features entirely new in connection with the making of star atlases. It is 28 inches square and contains an amazing amount of astronomical information. It covers the sky from the north pole to 40° south declination. The background is black, thus affording excellent contrast for the colors used. It contains images for all stars of visual magnitude brighter than 5.0, each image indicating, by its size, the brightness of the star, and, by its color, the spectrum classification of the star. In addition the positions of star clusters and nebulae are indicated. The right ascension and declination coordinates are clearly marked, and the constellation boundaries are clearly outlined. In a word, it answers practically any question that arises in positional astronomy, and a great many questions that arise in other connections.

It is truly a work of art and, in addition to its usefulness, it would also qualify as an adornment for the walls of any observatory or of any scientific library. C.H.G.